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INSPECTION AND MAINTENANCE OF RAILWAY STRUCTURES.

A DISCUSSION AT THE ANNUAL CONVENTION, JULY 2D–8TH, 1887.

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At the request of a number of members of the Society, a Discussion upon the Inspection and Maintenance of Railway Structures was announced for the Convention of 1887. A circular was prepared and issued, embodying a number of suggestions that had been made on the subject, and a request was made for discussion upon these and such other points as might occur to the members taking part in the discussion. The suggestions were as follows:

First.—What measures, legal or other, can be taken to insure a proper inspection of railway bridges?

Second.—What is proper bridge inspection?

Third.—Should there not be a standard specified rolling load much heavier than as now generally used, and a specified engine wheel base for rolling loads?

Fourth.—Is it not expedient to adopt a standard bridge floor?

Fifth.—Should not bridges of small span be made strong enough for a buckle-plate floor and a continuous coat of ballast on the bridge, and if so, up to what span should this apply?

Sixth.—Should not a safety guard (Latimer), be used at all openings over a certain width?

Seventh.—Should there not be required either overhead crossings, or, in their place, interlocking apparatus with derailing switches?

Eighth.—Is legislation as to any of these points, or as to any others you may suggest, expedient, and if so, what sort of legislation?

Ninth.—In this connection the experience of the Master Car Builders' Association has been referred to, which it is stated, has proved that the action of large committees reporting to the Association, and the adoption of standards after ample discussion, have been found very valuable.

DISCUSSION BY LETTERS.

JOHN A. WILSON, M. Am. Soc. C. E.—I have just received the circular relative to the maintenance and inspection of railway structures. The time is so short that I am not able to give this important subject the thought which it deserves and requires, and can only touch briefly on some of the points of inquiry.

QUESTION 2.—Assuming that reference is intended to bridges already in use, and not to new bridges to be built, I understand by proper bridge inspection, such examinations and oversight of a bridge by competent parties, as will insure the immediate detection of any defect or signs of failure or disarrangement of any of the parts of the structure, so that the condition of the structure may be positively known at all times.

Take a railroad bridge which has been properly designed and constructed. The bridge engineer having it in charge should have in his office full detailed plans of the structure, with strain sheets and calculations, and should know just what load the bridge will carry with safety. He should personally make a critical examination of the structure at least once a year, and oftener if his judgment indicates it to be necessary, and should hold himself in readiness to make a special examination at any time. He should keep a record of his observations, and of the reports made to him by his subordinates. A competent master carpenter or foreman of bridges should keep himself thoroughly posted as

to the condition of the structure, examining it once a month or oftener if necessary, and report in detail to the engineer. The road foreman or watchman should make a daily examination, and any defects that he may discover should be promptly reported to the master carpenter. When the engineer makes his examinations he should have the master carpenter and watchman or road foreman with him, confer freely with them on practical points, and see that they clearly understand their duties, what to look out for, and how to report. By this system the structure is under constant surveillance, and any defect should be detected immediately.

Where bridges have been erected and used for a considerable time without any oversight, considerable labor is involved in putting into operation a proper system of inspection. The bridges should be measured, examined and calculated, and full plans made, so that the engineer may have in his office exact information on which to base his operations. Without this, there can be no certainty about his work.

It is assumed as a matter of course, that when defects have been discovered the proper remedy will be applied.

In this connection it may not be out of place for me to say, that while we have in this country good bridging concerns who employ competent engineers, and turn out only first-class work, there are undoubtedly others which need the closest professional oversight, from the very commencement, to secure good designs, good material and good workmanship. The business of bridge building is free to all; the majority of people know nothing about it; they are told they shall have a good bridge, and when a bridge is finished and handsomely painted they assume that it is all right, while it may have the most glaring defects, and contain within itself the elements of speedy destruction. Much of the trouble with bridges in this country is due to original defects of design, material or workmanship, which no system of inspection can remedy, but can only point out. It would therefore seem as if inspection, to be complete, should include new bridges about to be constructed as well as those already existing.

Further, it should be noted that the designing engineers of bridges deal mostly with new structures which may be all right when erected, but may be put to uses for which they never were intended, and at best, will wear out in time like anything else. The maintenance of such structures under use is a business in itself, which can be learned only by practical experience. It is a business which the engineer who only builds bridges, and has no care of or responsibility for them afterwards, knows little about, whence the necessity for the "engineer of maintenance for bridges."

It is such an "engineer," in my judgment, that should have charge of the duties described above. He should not only watch the structure and discover its defects from time to time, but be able intelligently to

apply the necessary remedy, and no small part of his duty will be to see that loads are not placed on the structure which it never was intended it should carry.

QUESTION 3.—It would be difficult to establish an absolute standard of rolling load for the whole country, as the requirements and character of traffic vary on different railroads. Each railroad should establish for its own line a standard high enough to cover all contingencies, have the bridges conform thereto, and then make it a rule not to put more work on bridges than they are calculated for. The general tendency all over the country among transportation men, is, to increase the weight and dimensions of their rolling stock. They should establish a reasonable limit to which the engineer can work. The through bridges and tunnels now existing are the only things which control the height and width of passenger cars.

QUESTION 4.—It would certainly be well to decide on the best design of bridge floor, and have it brought into general use throughout the country.

QUESTION 5.—I am not prepared to answer this question. There are some practical difficulties in the way of adopting such a plan generally.

QUESTION 6.—It is very desirable to use a safety guard on bridges wherever practicable.

QUESTION 7.—My views on this subject are best expressed by the following extract from the evidence which I gave in a grade-crossing lawsuit in 1882.

"Grade crossings of railroads are very numerous in this country. When the country was new and traffic light, railroads were projected for local business, and necessarily had to be constructed at minimum expense, and grade crossings of different lines were allowed without much consideration. As the railroad system of the country has become extended, traffic and the speed of trains have increased, and the conditions of the problem have changed. The evil effects of grade crossings on leading lines have thus become more apparent, and while it is often difficult to change the location of a road after it has been in operation for years, and all the surroundings have accommodated themselves to the existing conditions, there is a growing feeling in the country in favor of a separation of grades—it is being done in some cases on existing roads at heavy expense, and there is a very decided aversion on the part of railroad managers to extend or repeat the evil in new construction.

The objections to a grade crossing of one railroad by another may be summed up under three general heads:

First.—Danger to life and property.

Second.—Delays to traffic.

Third.—Expense of operating.

I.—Danger to Life and Property.

This item cannot be entirely eliminated under any system of management. With the arrangement of signals now in use comparative safety can be secured—and it is undoubtedly a fact that grade crossings on important lines are successfully worked. Still there is left a percentage of danger—due principally to carelessness of employees or neglect to observe the rules; breakage of machinery about engines or cars on approaching a crossing, rendering it impossible to control the train; or error of judgment on the part of enginemen in approaching crossings under too much headway in bad weather with slippery rails, etc.

II.—Delays to Traffic.

It may be assumed as a general principle that the more efficient the signal system and the nearer the approach to absolute safety in the operation of a grade crossing, the more will be the delay to traffic. The amount of delay at any given place will depend largely on local circumstances and conditions, but it is nevertheless true that on any important line a grade crossing by another road must cause more or less delay, require a great amount of watchfulness, and be a constant source of anxiety to the officers and employees operating the road.

III.—Expense.

This item may be separated into two parts:

A. Those items which can be estimated in money, viz: Cost of crossing-plates and maintenance of the same. Cost of signal tower, etc., and maintenance of the same. Wages of emyloyees to manage signals, etc., with expenses for fuel, lights, etc.

B. Those items which, while appreciable, cannot be estimated in money, viz: Possible losses to life, limb, or property by accident. Value of time that might be lost by trains detained at crossing, and cost of stopping and starting trains, extra fuel consumed, etc. Increase in general operating expenses of road. Injury to rolling stock at crossing places.

A separation of grades should be had wherever it is practicable. If a grade crossing of one road by another cannot be avoided then every known safeguard, such as signals and interlocking apparatus with derailing switches should be provided.

Questions 1 and 8.—The general tendency in this country has been not to control the details of railroad management by legislative enactments, but to leave the railroads free to make their own regulations, holding them pecuniarily responsible for the results, it being supposed

that self-interest will properly regulate the matter. For many reasons it is desirable to follow this policy, but if the desired results are not obtained in this way, it may become necessary to establish legislative control. It is an intricate subject which would require careful study and elaboration, and cannot be hastily covered in a paper like this. Any legislative enactment on this subject should be had only after full discussion and consultation with the leading engineers and railroad men of the country. If a few of the leading railroad companies of the country would introduce a thorough and effective system of bridge inspection, recognizing the importance and necessity for separating the professional oversight of bridge work from its mechanical execution by contractors and bridge-building companies, the manifest advantage would soon be recognized, and public opinion would force the general adoption of the system.

The subject of grade crossings of railroads is one which, perhaps, more properly could be and should be regulated by law. Some of the States have laws on this subject, but they are generally crude, indefinite, and subject to local contingencies for their operation. In New York, a crossing of one road by another is examined into and decided on by a commission of three, one of whom must be a civil engineer. This commission decides whether the crossing shall be over, under or at grade. In Massachusetts, the subject is under the control of the railroad commissioners, who must give their consent before a grade crossing can be made. In Pennsylvania the matter is in equity proceeding before the county court, and the act of Assembly says: "And if in the judgment of such court it is reasonably practicable to avoid a grade crossing, they shall by their process prevent a crossing at grade." The practical effect of this act, is, a long trial, a lot of expert evidence both ways, and in the majority of cases a decision by the court that "it is not reasonably practicable to otherwise construct the crossing." It would be well if a definite policy in this matter could be adopted, with more uniformity in the laws of the several States.

WILLARD S. POPE, M. Am. Soc. C. E.—*Governmental Supervision of Bridges.*—It is probably generally believed that the State should exercise some intelligent and efficient supervision over all bridges within its domain. So far as is fairly possible the lives and property of its citizens should be safe while crossing such structures. An accident which might have been prevented by reasonable precaution becomes a crime.

It might be supposed that an enlightened self-interest would be a sufficient motive to insure good and reliable construction. When a railroad bridge falls, it costs the company a good deal of money, generally much more than the simple renewal of the structure, and the same

is true in event of disaster to a highway or country bridge. And so it would seem that self-interest ought to be an efficient safeguard. And in many cases it is. But there are far too many instances in which the persons in authority do not know, and are not competent to judge, of the strength and reliability of the structure, and many times even if they are aware of its weakness, they are inclined, from motives of false economy, to trust it a little longer, and to run some risk in order to delay a needed expenditure. And so by one or all of these reasons the life and property of the public are jeopardized. The matter is a reasonably clear one for the intervention of a higher power, and no power is so fit to undertake the responsibility as the Government.

But to act efficiently it must act intelligently. There is nothing mysterious or bewilderingly occult about a bridge. To the trained eye its defects, if any, are patent. But here, if anywhere, the trained eye is essential. Bridge wisdom is peculiarly a specialty. No one is born with it. Genius does not leap to it, nor does blundering stumble upon it. It comes only by patient study and long training. To pass judgment upon the merits of a proposed design for a bridge, or to reach an intelligent idea of the strength and trustworthiness of a structure already in use, requires not only common sense and sound business discretion, but also technical skill and experience in the details of that particular kind of construction, knowledge of the principles of computation of the magnitudes and effects of strains, and information as to the strength and capacity of materials. In brief, it is essentially and exclusively business for a trained expert. Therefore it is apparent that any control which the State may assume over bridges will be vain and useless unless it places the matter in the right hands.

To secure this result there should be, in my judgment, a commission organized by the State, to which should be relegated this whole business. All bridges within the limits of the State, whether for highway or railway purposes, should be included within its jurisdiction. A critical official examination should be had annually, or as often as might be necessary, of all existing structures, and reports be made thereon to the authorities in charge thereof, with such recommendations as the respective cases might seem to demand. If any structure should be found unsafe and the suggestions for repair or renewal were not immediately and properly complied with, the commission should have the power to order it closed to travel, and the town or company owning the same should be responsible in penal damages for any accident or disaster that might occur thereafter. The commission should prepare and publish such general specifications as to character and capacity of new structures as might be advisable under the varying circumstances, and no bridge should be allowed to be built except in conformity with the requirements of those specifications. All plans of proposed new bridges should be submitted to the commission, and receive its formal written

approval before work be commenced thereon, and all work in progress under such plans should be subject to its inspection, both as to quality of material and workmanship; and no new bridge should be opened for public use until it had been examined and approved. Plans of all bridges should be filed and preserved in its office, and these together with all its official proceedings should be always, under proper restrictions, open to the public. General designs might be prepared in detail and published, for spans of ordinary length and dimension, which could be used to advantage in many localities. In fact the operations and publications of the commission could not fail to be of great service in disseminating among those interested, useful and trustworthy information on the general subject of bridge building. Highway commissioners and town supervisors of bridges would find such suggestions and advice of great and permanent value. It would prove a school of technical instruction that would certainly be of much practical service.

In the above catalogue of the duties and powers of the proposed commission I would like it distinctly understood that they are not intended to interefere with or supersede in any way the duties and powers of the owners of bridges, whether towns or companies. The railroads and the town authorities will continue to have all the power and responsibility that they ever had. They will build, maintain and care for their bridges as heretofore, will inspect, watch over and repair them as they have always done. No responsibility will be taken from their shoulders, and none of their rights or powers will be invaded. The duty and authority of the commission is simply to see that the bridges as built or repaired are safe. The operations of the commission go hand in hand with, and not counter to, the operations of the bridge owners. They are friends and coadjutors, not rivals or conflicting authorities. They are to work together for a common end, and under proper management, instead of jealousies and misunderstandings, there will come friendly and hearty co-operation. All that the commission will demand and insist upon is safety, and that it is bound to have and will use all the authority in its hands to secure.

The commissioner or one of his assistants should accompany the railroad engineer or the highway supervisor on his periodical tours of inspection, and the needed repairs or renewals should be matter for free and frank consultation. The railroad managers and the county authorities should forward at once to the commissioner copies of any reports on the condition of bridges made to them by any of their subordinates, and, in short, all parties concerned should and could work together harmoniously and effectively for the common good. A faithful trial for a year or two would, I am sure, convince the most skeptical of the utility and economy of such a commission.

The commission should be headed by a man who is a professional bridge engineer of well-known skill, experience, tact and integrity.

Grave and weighty responsibility would devolve upon him, and he should have corresponding authority. To secure the greatest efficiency he should have the entire and unlimited control of the affairs of his department. He should appoint his own assistants and subordinates, fix their salaries and regulate all the expenditures of the office. If he is worthy of being appointed he is worthy of being trusted, and he should be entirely untrammeled and unhampered by political or other outside influence. He should be in every respect a first-class man, the best that could be got, and in his appointment nothing should be considered except his pre-eminent fitness for the special duties of that special position.

A man possessing such qualifications is not a common one, nor when found is he a cheap one. The salary and the term of office should be such as would justify the right man in accepting the position. He should receive at least ten thousand dollars per annum, and the term of office should be five years, subject, however, to dismissal for cause by the Governor.

The entire yearly cost of such a commission for this State (Michigan), thoroughly and actively administered, would, I suppose, be about forty thousand dollars. One-half of this sum should be paid directly from the State Treasury, and the other half by the railroads, being divided among them in proportion to their track mileage. If the commission were what it ought to be I believe the railroads would willingly assume this charge. The managers realize not only the necessity of having safe bridges, but also the desirability of public confidence in their safety; and surely the knowledge that such a supervision was had by disinterested and competent officials would tend largely to inspire such public confidence. The cost would be comparatively small for any one of the railroads, and they would thereby secure an additional and valuable inspection and supervision. From such a commission they would get help and not hindrance, co-operation and not annoyance. The commissioner and his assistants would be a corps of active and capable consulting engineers, the value of whose services would be worth to the railroads much more than the cost.

If this reasoning is applicable to the railways, it applies with much more force to the town and county authorities in their bridge work. These officers are, for the most part, honest and intelligent men, striving to do their duty to the best of their ability. In ordinary road and street work they are doubtless sufficiently competent, but in the technical details of bridges they are unskilled and uninformed, and they themselves are for the most part willing frankly to admit it. Such being the case, it seems reasonable to suppose that in these matters they would gladly avail themselves of the assistance of such a commission. Their real powers would be unimpaired. They would still decide as to the amounts of money to be appropriated, the method and manner of its

expenditure, the award of contracts, etc. The commission would be advisory, but in no hampering or offensive sense. The combination would work to the assistance of the town officers, and the public could be reasonably sure that it was not cheated by contractors, that it got its money's worth, and that it got good and trustworthy bridges.

So far as the cost of the commission is concerned the estimate of forty thousand dollars a year may seem large. But remember that there is a great amount of work to be done. There is in the State of Michigan nearly six thousand miles of railway, and probably ten times that length of wagon roads, and the aggregate amount of bridging must be very great. To properly look after all this will require a considerable force of men, and they must all be men of skill and professional training. And we should consider the magnitude of the interests at stake. A single bridge disaster may destroy in property, and in many instances has done so, tenfold the whole cost of such a commission, to say nothing of the loss of human life. If the object sought can be certainly secured by an annual expenditure of forty thousand dollars, there should not be a moment's hesitation. Such a sum is a bagatelle in the comparison. Possibly my judgment is at fault as to the precise amount. It may be somewhat more or somewhat less than the sum I mention. The precise amount needed can only be told by trial. There must be money enough to secure a first-class commissioner, and to provide him with an ample corps of first-class assistants, and to pay a considerable amount of traveling expenses, etc. The money which such an organization may cost will be well spent, and the staff will fairly earn every dollar that is paid them.

And now arises the question as to the selection of a commissioner. I think every one will admit that the office should be entirely and forever divorced from politics. It should be utterly beyond the reach of a party leader or a political striker. What is wanted is a bridge engineer, not a politician. Therefore it is manifestly out of the question that he should be subject to election by popular vote. He must be appointed. And who shall appoint him? Not certainly the Legislature. Any objections which apply to a popular election apply equally to such an appointment. The power might perhaps be placed in the hands of the Governor. But the Governor or any other individual or body that is elective might very possibly be swayed by motives more or less tinged by his or their political surroundings and affiliations. And furthermore, however conscientious and well-informed the Governor may be, it is not likely that he would be sufficiently acquainted with the subject or with professional engineers to be able to select the right man. Therefore the Governor is hardly the proper authority to make the choice.

The matter thus narrows itself down towards one and only one direction. The commissioner should be selected and nominated by those who will directly use his services, viz.: by those who have bridges to

build and care for. They best know what is wanted, and their acquaintance with engineers personally and by repute is such that they can most readily put their hands on the right man. They would be intimately brought into contact with him in the various operations of their daily business, and would carry a joint responsibility with him in all official transactions, and consequently would naturally feel the warmest interest in the character and capacity of the man with whom they had thus to deal.

Now, of those who have bridges to build and care for, there are two classes: first, the town and county officers in charge of bridge work, and second, the railroads. In the attempt to choose a commissioner, the first class would be heavily handicapped by reason of their great number, and by the fact that they are scattered all over the State in every township, and are for the most part unknown to each other, and so would probably find it impracticable to act in concert. And thus we come step by step to see that the selection of the commissioner should be by the railroads. And it is eminently fit that it should rest here. The railroads are vitally interested in the matter, and all their natural motives would be simply to get the best man. They operate a great number of bridges all over the State, on the safety of which incessantly depend immense values of property and great numbers of lives. They would pay directly one-half the cost of the commission. Their managers are few in number, acquainted with each other, and can easily act in concert. They are widely known to the whole community as men of character, capacity, intelligence and high standing. Their business connections are such that they are necessarily largely acquainted with engineers, and their means of information are ample as to the ability and standing of any individual. It might be reasonably expected that the man whom they should unitedly, or a majority of them, select would be fit for the place.

Let the Governor appoint the man whom the railroads nominate, put into his hands the duties and powers hereinabove indicated, and I believe a long stride will be made in the direction of public safety and welfare.

GEORGE H. PEGRAM, M. Am. Soc. C. E.—1. When we consider the number of bridges in this country, the experimental state of bridge building at the time most of them were built, and the rapid increase in loads and speed of trains, the number of accidents seems very small, and those which might have been avoided by inspection in the light of our present knowledge so small that there seems no justification in hampering the railway companies with legal enactments which might introduce greater evils through the divided responsibility which might ensue, particularly when the specification of bridge engineering and

inspection constantly tends to greater security and the railway companies evince a disposition to improve and renew their bridges as fast as can reasonably be expected.

2. Proper bridge inspection can only be made by a person thoroughly acquainted with the principles involved in the design as well as the mechanical manipulations through which the work has passed, and it is much better that such inspection be made at long intervals of time than that the work be subjected to the frequent torture that is now so common by unskillful hands. A complete record of every defect is of the greatest importance in order that chronic weaknesses may be avoided in future designs.

3. The rolling load on bridges is constantly increasing, and a standard would necessarily have to be heavier than that now in use to endure for any length of time. The real difference in the costs of bridges for light and heavy loads within the limits usually specified can be ascertained by railroads by asking for bids on both, and it is probable that when the small proportionate difference is seen the heavier load will generally be adoped. There seems to be no reason for specifying an engine wheel base when better results can be obtained in much less time with a uniform load in combination with a single concentrated load.

4. It does not seem expedient to adopt a standard bridge floor, because the proper floor to use will depend somewhat upon the construction of other parts of the bridge and there is a wide difference of opinion as to what is best.

5. A sufficiently good floor is made without the use of buckle-plates which contain elements of danger in their liability to corrosion and inaccessibility to inspection and painting.

6. An efficient guard rail is of all things the most important part of a bridge, because most failures of bridges are knock-downs. Rails, when used for this purpose, do not prevent the bunching of the ties, and it would seem that the case is most effectively and economically met by a wooden guard rail notched over the ties, and having an angle-iron nosing throughout its length, as I understand is used on the Chicago, Milwaukee and St. Paul Railway. In all cases, the ties should be sufficiently strong and well supported to carry a train when off the track. The addition of rails running to a point at the end of the bridge, as in the Latimer device, is, of course, so much additional security, and ought generally to be used.

7. It would seem desirable to require interlocking apparatus and every other known precaution at all crossings, but hardly practicable to make any limitations as to grade.

8. Legislation on any of the points covered by the suggestions in the circular would seem inexpedient, and a commission with judicial power in the selection of designs very much to be deplored, because the selec-

tion of men with sufficient skill and integrity, and, above all, free from personal bias and political influence, would be almost impossible, and the growth and development, now very rapid, might be seriously checked.

9. The experience of the Master Car Builders' Association in the selection of standards can hardly be properly cited in this connection. The devices discussed by them are nearly the same in cost and comparable in efficiency, while in bridge work it is frequently a matter of how much the road can afford to pay, and the efficiency is generally a matter of judgments born of different experiences. A poor bridge that stands does as effective work as a good one.

G. BOUSCAREN, M. Am. Soc. C. E.—I am prevented at the last moment from attending the Convention as I had intended to do. The time is too short now for lengthy remarks, but I am induced to say something in hope that it may bring about a full discussion from the able members present at the Convention; it seems very desirable that something should be done to rectify the course into which we are now drifting.

To question (3) of the circular, I reply, No, for the obvious reason that the weights of locomotives and trains vary within very wide limits from one road to another. Although it is good and prudent policy for every road to provide for the future in the construction of structures designed to be permanent, it can hardly be expected that a province road with light traffic, or a small feeder to a trunk line should make the same allowance in that direction as the main line of a great system with steep gradings and heavy traffic.

My reply to question (4) is that all bridge floors should be impenetrable to a derailed train; but to specify a uniform floor standard for all roads would be inexpedient for the same reason given against a uniform standard load.

Question (5). I would recommend ballasted floors on all bridges where creosoted ties are used, but would not put ballast on unprepared timber, and would prefer creosoted ties to buckle plates. The elastic medium offered by the wooden ties is, I think, very essential.

Question (6). Guard rails should be used on all bridges, and the Latimer guard or an equivalent substitute at the ends of all through bridges and of all high deck bridges at least.

I reply in the affirmative to question (7) which properly relates, however, to the subject of railroad crossings. For reasons already stated, arising from the great difference in the character and requirements of different roads, I would not consider it expedient and desirable that fixed standards of load, wheelbase, floor and guards be legislated, but I think it is of the greatest importance that proper inspection be enforced by the States or by the general Government.

This inspection should not consist in an "intelligent walk" over the structure or a "good glance" from the rear platform of a Pullman car, but in the verification of the facts as to whether a bridge is, or is not, properly adapted to the purpose for which it is being used: or in other words, whether it is properly designed and proportioned, first to carry safely the maximum load to which it is actually subjected; second, to resist the abnormal effects of accidental causes, such as extraordinary wind storms and the derailment of trains, and whether it is being properly maintained, as to repair and adjustment of parts, and the protection of its material against natural deterioration.

We all know why so many poor structures are to be found on some otherwise first-class roads, but it may be well to speak out the reasons here.

Let us assume the most favorable circumstances: a road is being built under the supervision of an engineer who, perchance, happens to know something about bridges. He prepares his specifications for the heaviest load used in the country, and adds something to it to provide for contingent increase in the future; this does not suit the president of the company, who is a practical man; he does not propose to build a road on the model of the Pennsylvania or the Baltimore and Ohio; he wishes to provide only for the traffic in sight, and is not going to have heavy engines to bend his rails—he directs the engineer to change his load. The road is built, the engineer is dispensed with of course; a carpenter is in charge of the bridges; he can frame and put up a Howe truss, but he is not "at home" with his iron bridges—they rattle some and are getting rusty—he screws them up!

The weights of engines and trains on the road are increased fifty per cent. by the force of circumstances, and the bridges are still standing, but for how long? This is the early history of a great many American railroads. Now comes on other trouble, it first began with steel rails. What is wanted are rails that will not break like glass or crush like lead. Engineers have tried to learn what little is known with regard to steel and to utilize this knowledge in specifying some of the qualities which appeared essential to have in the steel they were buying. Manufacturers have taken exception to this and have so resolutely and unanimously set their heads together against this presumption of the engineer, that it is next to impracticable now to have rails made on specifications here as is universally practiced in Europe; perhaps this may have a bearing on the marked difference which has been apparent lately in the lasting qualities of American and European rails.

A movement in the same direction is now being made by some bridge manufacturers: they have specifications of their own which they propose to substitute for engineers' specifications; some deal with the quality of materials only, others with the workmanship, load, and the proportioning of parts as well, and the proposition sometimes takes the shape of an ultimatum, "You shall have this or nothing."

Grant the same degree of unanimity and cohesion to the bridge builders on that ground, as obtains for steel rail manufacturers and there shall be no more need for the engineer, except, perhaps, as experts called upon to unravel the mysteries of bridge wrecks, before a coroner's court. I do not wish to ruffle the feelings of my friends, the manufacturers, nor to impeach their ability, nor to impute their motives, but I believe it is an unsound principle and an ill-advised business move to dispense with the intermediacy of the engineer between the buyer and the contractor. It may suit the purpose of contracting companies admirably well, but I believe it is not calculated to promote the interests of the public, the progress of the art, nor the high repute of the profession, yet this is the drift of the situation, and I could not suggest a better remedy than rigid legislation on the proper inspection of railroad bridges.

W. S. LINCOLN, M. Am. Soc. C. E.—In reply to your letter of inquiry I desire to submit the following replies to your inquiries:

QUESTION 2.—In addition to the daily inspection made by the bridge watchman, an inspection should be made every thirty days by a careful man skilled in erection and accustomed to the care of tracks, approaches, etc., who should make careful report of the condition of the whole structure as far as it may be apparent to him. An additional inspection should be made by a competent engineer at least every six months, who should carefully examine every part of the structure and make reports to the Chief Engineer.

QUESTION 3.—I am inclined to the opinion that a standard specified rolling load should be adopted and also specified engine load and wheel load.

Many of the roads have adopted what would seem at present to be in excess of what is required, but as the practice seems to me to increase the weight of the rolling stock and loading it must be considered a step in the proper direction and as "taking the safe side." It may be urged by some of the advocates of lighter loads that many of the smaller roads having light engines do not require such heavy bridges. The live load from the general car loading will be the same for every road in the country, and if the heavy engines are economical and desirable for the larger roads, they will ultimately come into general use, and there should be no more permanent iron work built for light loads.

QUESTION 4.—I think it would be expedient to adopt a standard bridge floor, and enclose a plan, Plate XLI, of such floor as I have had in use for many years.

QUESTION 5.—I see no necessity for a buckle-plate floor and am not in favor of it. It is objectionable for various reasons—difficulty of making

repairs—in the way of painting and inspection—increasing liability to corrosion.

QUESTION 6.—The Latimer or some equally effective appliance should be used at all openings over 20 or 30 feet depending somewhat upon location.

QUESTION 7.—Crossings of other roads should be overhead when possible. If this is not practicable, interlocking apparatus with the derailing switches should be used, and this should be enforced by proper legislation, though as to this, each road should certainly take its own precautions as to the safety of its structures and should be held responsible for the results. The inspection should be thorough and made by a competent engineer. A superficial examination, such as is frequently made, should not be permitted, and, if necessary, laws should be enacted to enforce such inspection.

QUESTION 8.—A committee to discuss these matters would be ultimately productive of great good, and as in many other similar cases lead to some understanding as to uniformity of practice. I hope to see this matter taken up with a view of further action.

JOSEPH M. WILSON, M. Am. Soc. C. E.—I confess to not being very familiar with the powers possessed by Congress, as compared with those of the States, for framing laws governing matters of proper strength in railroad constructions, but the vast extent of our railroads, spreading all over the country, in utter disregard of State lines, the same road often running through several States in succession, and the applicability of a common law for all, would appear to make it advisable, if possible, that the Bridge Inspection question should be controlled by Congress rather than by State laws.

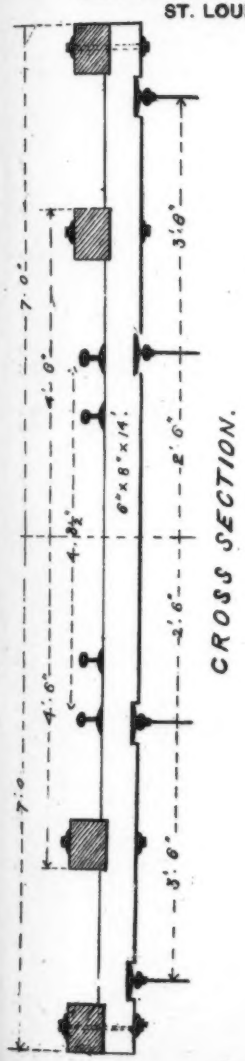
The common custom and great advantages of running through lines for very long distances and of transporting freight and passengers from one road to another without change of cars or break in bulk; also the tendency to uniformity on the various leading roads in engine service for the several classes of engines, all conduce towards a similarity of rolling loads, and render it advisable, if possible, to adopt a standard specified loading for bridge computations. If, in arranging this, an assumption can be made that would include the effects of both cars and engines, it would lead to simplification.

So many changes are being made from time to time, particularly in engines that if a standard were adopted for the engine loads, conforming to or covering a particular series of engines, it would not remain standard very long, and therefore it would seem best if engines are to be considered separately, to assume a typical engine, designed not only to cover existing types, but to anticipate the outcome of the future. It would seem, however, that one might be able to work up a loading that

PLAN OF STANDARD FLOOR SYSTEM —FOR— IRON BRIDGES.

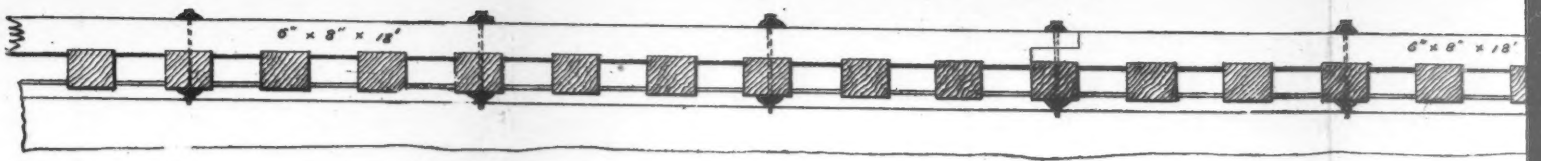
WABASH WESTERN R'Y,

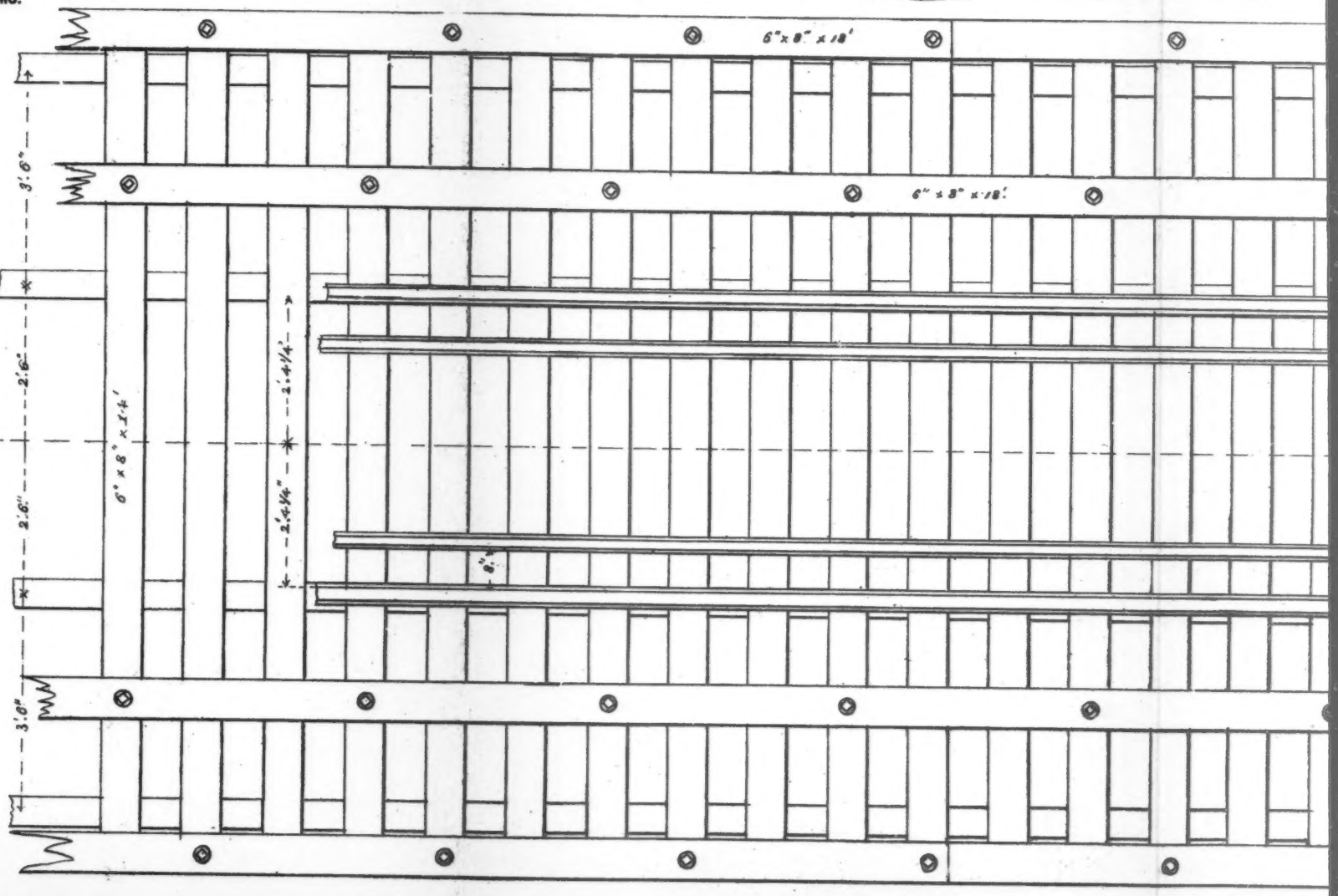
Office of CHIEF ENGINEER,
ST. LOUIS, Mo.



CROSS SECTION.

SIDE ELEVATION





TOP VIEW.

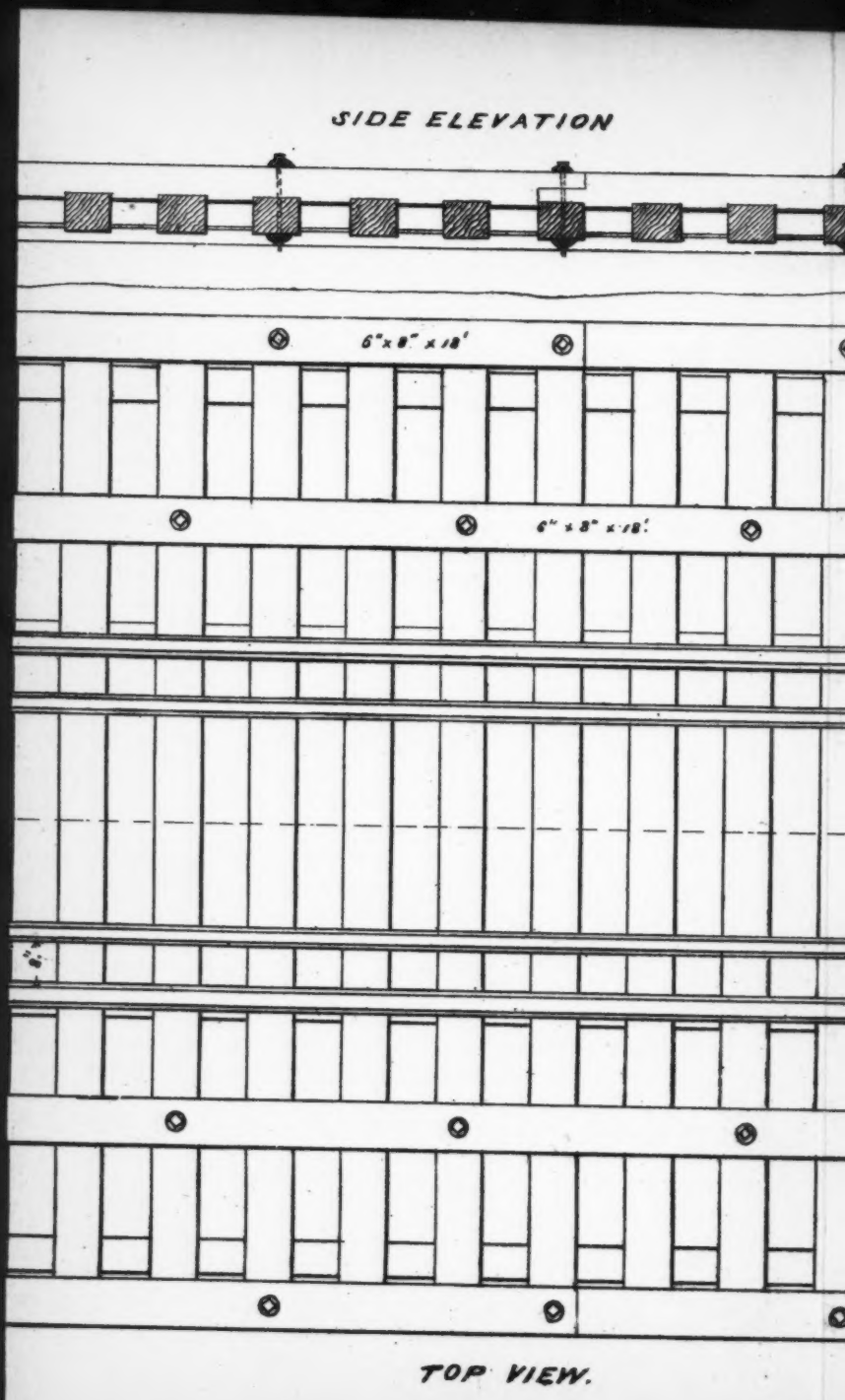
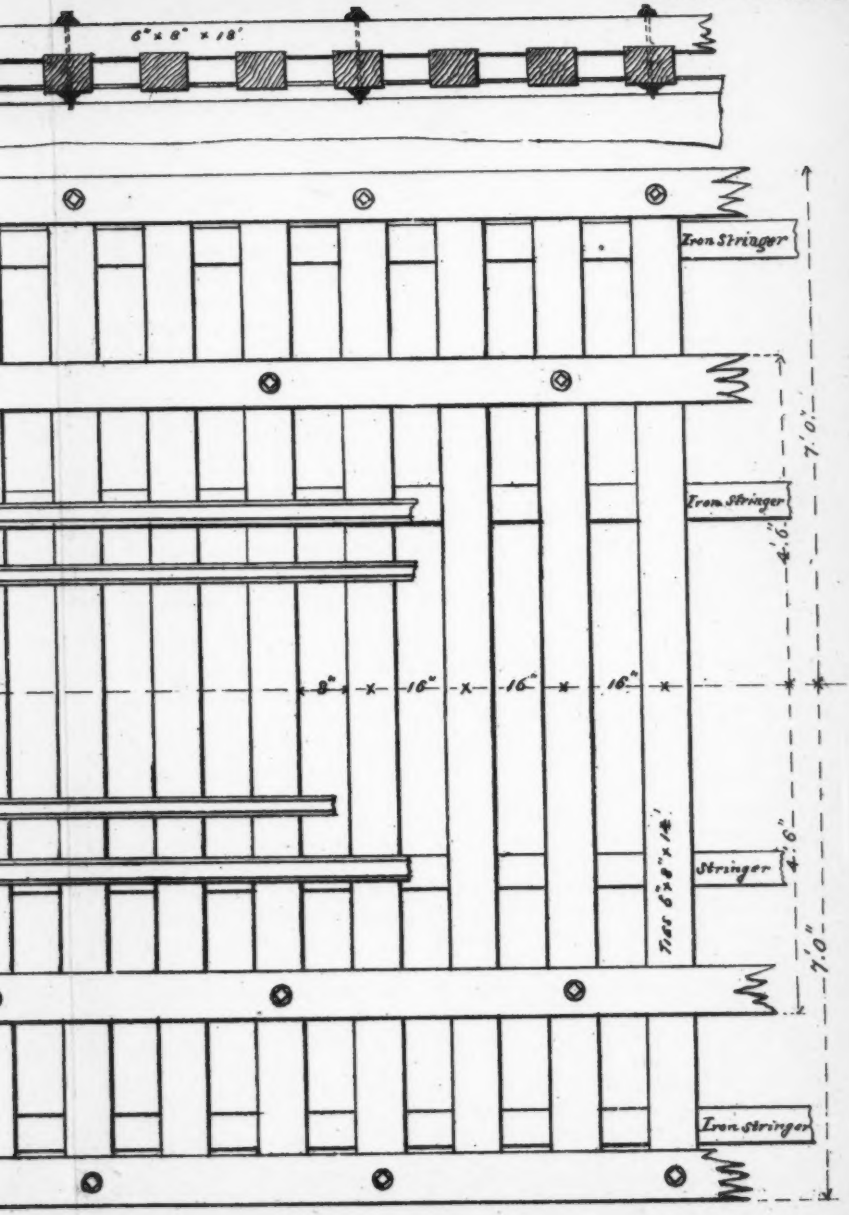

SIDE ELEVATION
6"x8" x 18'
6" x 8" x 18'
TOP VIEW.

PLATE XLI
TRANS. AM. SOC. CIV. ENGRS.
VOL XVII Nº 372.
LINCOLN ON
BRIDGE FLOORS.



would cover both engines and cars, particularly as the present tendency is to make a large margin in loadings, and this margin would probably be sufficient to include not only all variations of locomotives, but the differences between their loads and those from trains. The matter would require more care and study than can be given at this time, but there are certainly possibilities in this direction, and it would be a great point if there was a standard established by law for the designing of all new bridges.

Where old bridges are to be inspected, criticised and accepted or condemned, proper economical considerations would demand that they be considered in reference to the actual service that they have to undergo. Branch roads, with light trains at long intervals, would answer with lighter bridges than a main line with heavy traffic and frequent trains, and an extensive road with branch lines can often replace its light main line bridges by heavier ones, using up the old bridges on the branch lines. I do not mean to have it inferred from this that I favor light bridges on branch lines. By no means. Where a new bridge is to be built for a light branch road, I would always build it up to standard, as in the various changes in the direction of traffic, to which experience can well testify, no one knows how soon a branch line may become subject to heavy service. So far as the framing of a law is concerned to govern this subject, railroads might be classified as say first, second and third class, depending upon the kind of business and loads carried over them, and the operating companies could be prevented by penalty from placing a heavier class of business upon a line than that for which it is registered.

For the designing of new bridges, I am decidedly in favor of a considerably heavier live load than that generally used. I believe I was the first to inaugurate the system of using typical designs representing engines of the future for loading, and my experience with their use shows that it only took about eight years to reach with actual service the advanced limits, which, at the time they were adopted, it was supposed would cover the case for many years to come. This experience justifies me in saying that I think this limit for live load should be made much higher than it generally is. That recently authorized by the Pennsylvania Railroad meets with my approval, and as this road is a very prominent one in extent and position, and the question of coming to some uniform standard is a very important one, I should be in favor of adopting it. It is only an amplification of what I have been endeavoring to work up to for years.

I am not yet converted to the English system of loading small bridges with solid floor and ballast so as to increase the proportion of dead to live load, but I thoroughly believe in making them much stronger than long spans, in proportion as they are smaller, and the live load increases in comparison with the dead load. I would rather reduce the allowable stresses per square inch than increase the dead load.

The adoption of a standard floor system would be a good move if it could be done. But it would be almost impossible to get all engineers to think alike on this matter. I have known those who adopted standards, and frequently found reason to change them afterwards.

I do not like any guard system which provides for guards placed inside of the rails, but much prefer them outside, where they are far less apt to give trouble in case of obstructions falling on the track, and to my mind outside guards can be made equally effective for their purposes as inside ones.

My idea of a properly organized system on a railroad for bridge inspection and maintenance would be something like the following:

There should be a complete tabulated list of all the bridges on the road kept on file in the proper office of the company, that of the chief engineer, the engineer of bridges, or the office representing that branch of the service. If the extent of the road is sufficient to justify it, there may be an engineer of bridges in general charge of this whole department.

This list should give the bridges according to number, first over the main line and then on the several branches from their junction, showing location, kind, size, general dimensions and other particulars.

Then there should be on file in the same office a complete set of drawings for said bridges, showing not only the general plans but complete in every detail, with strain sheets calculated under certain assumed loading, so that a competent engineer may, by examination of these plans, satisfy himself as to the proper design, proportions and strength of each structure, not only as to its general parts, but for every detail. Whenever any changes are made these lists and plans should be kept corrected up to date.

In taking up the bridge question for a road where very little attention has previously been paid to it, one of the first things to do is to prepare these lists and detail plans, and to have full computations made on each bridge, not for an ideal load of the future, which is a question for new bridges, but for the actual loads in use.

With this data before him, the expert engineer can determine how far each bridge is adapted to safely carry the service put upon it, and how far he can allow parts which may be light to fall below the standard limits without condemnation.

He will now proceed to make a close personal inspection of each structure, not only to confirm his theoretical deductions but to examine for faults, decay, breaks, wear and tear or other practical questions which may affect the case more or less seriously.

Each division of the road, such as is covered usually by a division superintendent, say one hundred and fifty miles or more in length, should have on it an assistant engineer, one who is a graduate of a reputable scientific engineering college, who has had some years' actual service on a road under operation, and who has had some experience in bridges.

With him, and under his direction, should be what in the old days of wooden bridges was designated the "master carpenter," but who in these days might have a more appropriate title, such as superintendent of bridges, or something better. This man should be eminently practical. He should understand how to handle and use workmen and mechanics, how to frame and erect wooden bridges, Howe trusses particularly, trestles, false works, how to erect and repair iron bridges, even if it may not be desirable for him to actually undertake the work of erection, and he should know something of the general principles of the action of bridges.

All matters of maintenance would come directly in his charge, under the assistant engineer.

These two men, the assistant engineer and the superintendent of bridges, should work together. On them rests the direct responsibility for the care of the bridges; the daily, weekly or monthly examinations, as may be necessary, are to be made by them. These should be supplemented by the daily inspection of the road foreman, whose duty it should be to go over his subdivision each day, and to examine for defects not only in track but in bridges and everything else on the line. If matters occur that require prompt action they are to attend to them, and to report to higher authority, by which they would always be governed in any expenditures, modifications or changes of structures. If they need further expert examination they can ask for it. They have the direct responsibility, and must take any instant precautions necessary for safety, so that no risks may be run.

After the first detailed examination by an expert, whether a regularly appointed engineer of bridges or only called in for the occasion, together with the preparation of detailed plans, etc., copies of which should always be on file in the office of the assistant engineer of the division, then further inspections by experts may be made only once per year, or, perhaps, say once in two years, with special inspections as may be required, to be made by the engineer of bridges or a specially appointed consulting engineer, but one who necessarily must be an expert in his particular calling. The annual inspection is only an ordinary one, which, of course has grave responsibilities connected with it, but it is not intended to relieve the responsibility of those who have direct charge of the bridges. It should be made in company with the assistant engineer and superintendent of bridges who should, in any examination report freely for the benefit of the expert, all facts concerning the working of the structures under service, and ask for advice where wanted. The inspector, on his part, being familiar previously with all theoretical deductions concerning the bridges, or having them before him, should advise, give instructions and directions, make his own notes and embody the results of his examinations in a report to the proper officer of the road.

After such work is regularly organized and goes on from year to year, each bridge gets to be thoroughly known on its merits, as to its details, its peculiarities and its capabilities. All is under proper control, and repairs, strengthening or renewal will take place in due season as needed, based on the reports made on the structure. If these reports are faithfully made by a competent man, and the advice therein given is conscientiously carried into effect by the railroad company, there is no reason why the traveling public should not be efficiently protected.

JAMES G. DAGRON, M. Am. Soc. C. E.—1. It is, in my opinion, desirable to avoid the interference of the National or State Legislatures in this connection. Any law framed by non-experts could but be deficient and ill-considered, and should such legislation be passed it would probably either add to the powers of the railway commissions in the States where they exist, or create a corps of State Inspectors of Bridges who would be appointed officers. These officials might, in rare cases, be competent men, but there is a strong likelihood of their being appointed more on account of their political influence than of their professional standing and experience.

The remedy lies in the hands of the railway companies themselves, inspection of railway structures is not a new art, and the services of competent and experienced men can be readily obtained.

Every railway company whose mileage is sufficient to warrant it, should have a Superintendent of Bridges on its permanent staff. This official should be an engineer, fully capable of determining the stresses induced in the structures, and thoroughly versed in the practical details of the manufacture of the different parts, and in the characteristics of the material; he should make a thorough inspection of all structures on the line of road at least every six months, and preferably at shorter intervals, reporting their condition to the executive officers. Bridge watchmen, trained by the Superintendent of Bridges as to the points to be noted, should make more frequent examinations of the structures under their charge, reporting at once to him anything amiss discovered by them. In the case of roads whose mileage is not great enough to warrant the permanent employment of an expert, one should be called in at least once every year to make a thorough inspection of their structures, and he should instruct the bridge watchmen as above stated, they in this case reporting directly to the proper officer.

2. Proper bridge inspection consists in a careful and minute examination of all the parts of the structure, both as to their construction and as to their action in service. It should be seen that each part is doing its proper duty and in condition to continue doing so.

All bridges during their construction at the shops should be carefully inspected and the material entering into them properly tested.

This work should be in charge of thoroughly competent men, and not, as is too frequently the case, in the charge of those neither theoretically nor practically qualified for the work.

3. There is no doubt that a revision of specified rolling loads is advisable, as in some cases the actual loads now in use and coming into use exceed the specified loads. It is questionable however whether a standard could be adopted satisfying all conditions.

4. I think that a standard bridge floor could be adopted after full discussion. Such a floor should be strong enough to carry safely a derailed engine or train, the spaces between ties not exceeding four inches. The ties should be notched one-half inch over the stringers, every third tie being fastened to the guard rail and stringer by a $\frac{3}{4}$-inch bolt and intermediate ties fastened to the guard rails by $\frac{5}{8}$-inch bolts, the dimensions of ties to be determined by the distance apart of stringers but to be not less than eight inches deep. Guard rails to be 6 x 8 inches and notched one inch over ties.

5. It would be advantageous in many respects to have bridges of small span made strong enough for a buckle-plate floor, and a continuous coat of ballast on the bridge; such bridges would afford more resistance to impact and vibration, thus adding to their life. This is the general practice in Europe. I am not prepared to state up to what span this should apply.

6. I am heartily in favor of the use of a safety-guard (Latimer, or one equally as good) upon all structures exceeding sixty feet in span.

7. Overhead crossings should be required except when absolutely impracticable, and in this case interlocking apparatus with derailing switches should always be used.

8. Legislation is to be avoided as much as possible, and, if necessary, to be only asked for after complete study of the question by experts and on their recommendation.

9. I would suggest the appointment of a committee, taken from the Society, to thoroughly study the question and to report at the next annual meeting or next annual Convention.

J. A. L. WADDELL, M. Am. Soc. C. E.—1. Let the American Society of Civil Engineers present a memorial to Congress suggesting that laws be passed which will compel every railroad company in the United States to have prepared and filed, either at Washington or at the capital of the State under which the company was chartered, a report by a duly qualified expert upon the strength and capacity of every bridge upon that company's lines.

This report should consist of a diagram showing sections of all main members and the stresses to which they are subjected by the standard

maximum load adopted by the company for the portion of its line upon which the bridge is located, and which load the company under no circumstances should be allowed to exceed.

It should also contain sketches of all details showing clearly the sizes of all parts of each connection, the chord packing, riveting, and all other information that would be necessary for an engineer to enable him to report upon the structure.

In addition to the preceeding it should give the inspector's opinion as to the real capacity of the bridge, considering both the main members and their details, with suggestions as to what changes should be made in order to have the structure comply with legal requirements.

The railroad company should be allowed a reasonable time for making these changes, the length of same depending upon the gravity of the defects; and, in case of non-compliance, proceedings to stop traffic should be undertaken by the Government.

If the railroad company refuse to accept the inspector's report, the matter should be referred to a standing committee, whose action on such matters should be final.

To prepare the laws relating to inspection and capacity of railway structures, a committee might be appointed, thus: The Government to choose a prominent member of the legal profession who has had experience in railroad matters, the president of the American Society of Civil Engineers to appoint two bridge experts, and these three to choose another prominent member of the legal profession and a railroad engineer of great experience and established reputation.

Let the committee make a classification of roads according to the character of their rolling stock and amount of traffic, then prepare general specifications for bridge design so complete as to cover every detail, these specifications to be used for all new bridges, old bridges being allowed a certain percentage or certain percentages of deviation from the requirements.

After the passage of these laws, let the Government give authority to the American Society of Civil Engineers to appoint a board of bridge experts, to acts as examiners of applicants for the position of "qualified bridge inspectors." The members of this board should be engineers who are located all over the country, so as not to require an applicant to travel any further than can be avoided. Any one member might hold an examination (written), the questions being prepared by a committee of the board and sent under seal to the applicant in care of the examiner.

Each member of the board should see the examination papers and mark them, the average of all marks determining the passing or rejection of the candidate.

In case of any three members of the board being able to meet to hold an examination, the latter might be oral and the candidate be passed or rejected solely by these three members.

No one who is not a full member of the American Society of Civil Engineers should be allowed to have an examination; but if this arrangement be adopted, the methods of voting upon candidates in the American Society of Civil Engineers should be modified.

A candidate should be required to have had ten years' practical experience (or, if a graduate of one of certain specified technical schools, six years') including at least three years devoted to bridge work. By following this method none but really competent experts would be appointed.

The Board of Examiners should have the power to, at any time, annul the certificate of any inspector, when proper reason therefor exists.

Maximum charges for inspection should be fixed by the Government, but these limits should be high and based upon a salary of at least one thousand dollars per month. Otherwise competent engineers would not care to practice at bridge inspection.

2. There are two kind of bridge inspection, viz.:

A. Inspection of structures whose dimensions are not on record.

B. Inspection of structures whose dimensions are on record.

The former is, of course, much more extensive and thorough than the latter. It should be made as follows or in some similar way:

I. Measure systematically the main dimensions of the structure and the sections of all the principal members, recording them always in a certain manner, determined by experience to be the best, so that any particular data may be found immediately by inspecting the field notes, which, by the way, should be made in ink.

II. Measure and record systematically the sizes of all parts in the neighborhood of each panel point and each connection of main members, showing number, spacing and diameter of rivets, the packing, including the distance of center line of each piece from plane of symmetry, dimensions of eye-bar heads, thickness of bearings, and, in short, every dimension that could under any circumstances be required.

III. Measure and record systematically all the details of main members between panel points or connections, for instance, sizes of lacing bars, stay plates, stiffening angles, etc.

IV. Examine the structure carefully to find any faults in manufacture or design, such as loose or unequally strained tension members, bad packing, omission of fillers, bad riveting, twisted or otherwise distorted members, inefficient bracing, loose connections, etc., also the effect of wear such as loose rivets, bent pins, rust, decayed timber, cracked castings and defective masonry or other material at pedestals.

V. Look to the efficiency of the floor system proper, viz.: the ties, rails and guards, also to the means of protecting structure from injury by fire, derailment, vibration, etc.

VI. Examine thoroughly and make notes upon the substructure, giving the principal measurements, quality and condition of materials,

etc. Describe the crossing of the stream or chasm, noting if possible, high and low water, velocity of stream, and any other information that may be of use.

VII. Note the effect upon the bridge of rapidly passing trains, measuring and recording, if thought necessary, the deflections.

VIII. Note if possible names of designer and manufacturer and date of erection.

IX. Record in note-book the names of the members of the inspecting party, the date and the time spent in making measurements.

The inspection of structures whose dimensions are on record should be made simply with the view of ascertaining the effect of wear upon the structure.

The items are mentioned under the previous headings numbered IV, V, VI and VII. Before making such an inspection the inspector should read carefully the notes of the previous inspections, and determine where to look specially for the effects of wear.

3. There should be not one but a number of standards for rolling loads, graded according to the train weight and the present and probable future traffic.

It would be a great waste of money to require the small western roads to adopt bridges calculated to carry the heaviest traffic in the country. It is no serious matter for a railroad company to remove and replace a structure that is too light for an increased traffic; for the light bridge can generally be used on one of their branch lines, or, if well designed, be sold to some other road.

For proportioning the floor system and primary truss members the amount and distribution of weight of one or more standard typical engines should be used, but the chord stresses of trusses should be calculated for a uniformly distributed load, and the web stresses of trusses for another uniform but advancing load headed, if thought necessary, by an engine excess and even followed by another engine excess, if so much refinement of calculations be considered advisable.

The second engine excess could be assumed at the nearest panel point.

The ultra refinement of calculating the effect of engine load concentrations upon main members of trusses can be fully appreciated only by the computers of bridge companies whose time is utterly wasted in this manner.

It seems hardly necessary to mention that the equivalent uniform loads for both chords and webs should vary with the length of span.

4. It is, indeed, most expedient to adopt a standard bridge floor. The requirements for same should be :

I.—That it carry safely across the structure a derailed locomotive or train without moving out of position a single tie.

II.—That it be designed to prevent the starting of vibrations that would be prejudicial to the structure.

III.—That it provide a place of refuge from passing trains for persons on the bridge.

IV.—That its cost be made a minimum.

To accomplish the above the writer would recommend that the stringers be placed directly under the rails, that the ties be of 6 x 8-inch timbers laid on flat and spaced twelve inches centers, that every sixth or seventh tie extend over the whole clear width of structure so as to support at each end a longitudinal 3 x 12-inch plank for a foot walk, the remaining ties not exceeding seven feet in length; that every tie be bolted at each end to the stringers or to wooden shims resting thereon, and which are rigidly bolted to same; and that no outer guard rails be used, but instead inner guard rails of angle-irons placed about six inches clear of the rails and bolted to alternate ties, these guards to extend on to the embankment, where they should be drawn gradually together and terminated by an acute-angled frog.

5. Yes. The limit of pin-connected spans should be not less than one hundred feet, but lattice girders, as ordinarily built, should be ruled out, and single intersection triangular riveted girders used instead, great care being paid to the proportioning of details, and metal and rivets being used liberally in the design.

6. By all means, and the limiting width should be small.

7. Yes, in districts at all thickly populated; but not for some time to come upon the roads of the far West.

8. Legislation as to all these points is not only expedient but is fast becoming an absolute necessity. The condition of many bridges, especially in the West, is something frightful. Any man has the right to call himself a bridge builder and to help fill the country with man-traps of the worst description.

There are many bridges in the West in which the iron is every day over-strained from fifty to one hundred per cent.—this under the assumption that the live loads are applied without impact, while in reality the structures are so loose-jointed that the vibrations induced thereby must cause the dynamic effect to increase the calculated stresses by at least fifty per cent.

The difficulty is and has been that railroad managers and chief engineers, capable men as they generally are, are entirely incompetent to pass judgment on the merits of bridge designs submitted for their approval, so they generally let the work to the lowest bidder and thus accept in many cases the most inefficient design.

They have a notion that they are possessed of very sound practical ideas about bridges, while, in truth, they are ignorant of the first principles of design.

The only safe method for such men to adopt is to employ the services of an expert in bridge designing, and the only safe method for the country in general is to pass a law compelling all railroad bridge companies to submit both diagrams of stresses and working drawings for approval by either a State Bridge Engineer or a board of engineers legally appointed.

9. There is no method which will have a more beneficial effect upon the quality of future bridges than that of organizing an association of bridge designers and builders for the purpose of discussing bridge designing in all its details with the ultimate object of adopting standard bridge specifications so complete that upon looking over a design any competent engineer can determine, without any doubt, whether the proposed structure be fully up to the specifications in the most minute particular. Such an idea is by no means Utopian, although it will no doubt be characterized as such by many engineers.

It might take several years to arrive at the object of such an organization, but if the latter were composed of the right kind of men, and if a committee of them were well paid by the Government for their time, and permitted to make experiments upon bridge material with Government money, there would be no doubt about its success. If the Government is willing to spend millions upon a study of the physics and hydraulics of the great rivers, why should it not be willing to devote a million or even half a million of dollars to the investigation of how to build first-class bridges at the minimum expense?

Can any engineer have any doubt about the value of such experiments, if made systematically and with a practical object always in view when making each experiment?

At the meeting of such an organization every word spoken should be recorded, printed and distributed for further comment. This would result in obtaining the views of engineers not in the association, and in insuring to every man in the profession an opportunity to present his opinions to the public, if said opinions were worthy of such presentation.

Why cannot such an organization be formed under the auspices of the American Society of Civil Engineers?

E. S. PHILBRICK, M. Am. Soc. C. E.—I have hurriedly put down something in reply to the circular. It is based upon our experience in the State of Massachusetts, where legislation through a railroad commission has done much, we think, towards an enlightened guidance of railway administration on such points as regards the public safety. The cardinal principle with us is publicity in all facts, and the strict accountability of every corporation to an enlightened public opinion. Our commission has done much, we think, too, towards educating and creating such a public opinion, which, in a democratic community is a mighty sovereign.

1. Railways should be required by law to file plans and specifications describing each of their bridges in detail, with such uniformity as can be secured, in the office of a State Board of Commissioners who should be authorized to employ experts to examine and report upon the sufficiency of such plans, etc.

An annual inspection and report should be made upon every bridge by an inspector in the employ of the owner of such bridge.

2. Proper bridge inspection should include:

(*a.*) An examination of the strain sheet to see if it is based upon proper loads, and that it is computed to show the maximum strains.

(*b.*) An examination of the dimensions of every member to ascertain the actual unit strains by comparing with strain sheet.

(*c.*) A search for signs of depreciation and wear, such as loose rivets in riveted members, excessive deflection under rolling loads, inefficient lateral bracing, loose bolts or screws, rust. Hidden parts, not accessible to paint or to vision should be condemned.

(*d.*) Change of form in any combination or single member.

3. Prudence requires us to anticipate the future possible and probable increase of the weight of rolling stock by using heavier standards than those in actual use upon any railway in question. But it may not be proper to apply the same standard indiscriminately to all lines. Regard should be had to the probable nature of the traffic and whether or not it is connected with other lines from which traffic is received from remote parts or whether it is comparatively isolated and independent of foreign rolling stock. For all trunk lines which look for a large traffic from considerable distances a standard rolling load and wheel load with axle distances for locomotives could and should be adopted.

4. Standard should be adopted for bridge floors, varying somewhat according to the volume and nature of the traffic.

5. Bridges with buckle-plate floors and continuous ballast afford the advantage of a more smooth and noiseless track and greater security in case of derailment, but they are open to the serious defect of concealed rust, and are, in the writer's opinion, not to be recommended for this reason.

6. Some safety guard should be applied at all openings in the road bed over ten feet in length.

7. Level crossings should never be allowed for tracks used by different administrations, unless protected by interlocking signals and derailing apparatus or its equivalent.

8. Legislation is expedient if so arranged and guarded as to never relieve the railway company from its responsibility in case of neglect or break down. It is preferable to have a State Board of Commis-

sioners, whose duty it should be to see that all railways within each State conform to statutes and to all reasonable safeguards. Publicity through such a board can effect much reform, though their efficiency must largely depend upon the earnestness, tact and industry of the members.

9. It may not be so easy to induce any considerable number of railway superintendents to meet and discuss such subjects as in the case of manufacturers of rolling stock, but if they could be so induced, much good would result by the interchange of ideas and the broadening of views among men who are tempted to become routinists from living in too narrow a circle.

ANDREW BRYSON, M. Am. Soc. C. E.—In reply to your circular relating to the inspection and maintainance of railway structures, the following is submitted, embodying in as concise a manner as possible, some of the writer's ideas concerning the questions therein asked.

1. What measure, legal or other, can be taken to insure a proper inspection of railway bridges?

Compel, by act of Legislature, every railway company to either keep in their employ competent men to inspect their bridges, or to have an inspection made at least once a year by some competent outside engineer; also furnish strain sheets and detail drawings to the Railroad Commissioners, who should have a sufficient force of experts in their employ to verify the proportioning of parts, and, if deemed necessary, verify also the structures as built and see that they correspond with the drawings and calculations. A printed form for inspection reports should be prescribed to be filled out by every inspector, for each structure examined, showing in minute detail, when and how the examination was made. These reports to be made in triplicate. One copy to be retained by the examining engineer, one to go to the railway company and the other to be sent, by the inspector, to the Railroad Commissioners, each one to be signed by the inspector, with date and post-office address subjoined.

2. What is proper bridge inspection?

It consists of two separate and distinct examinations, one purely theoretical and the other practical; either one alone is little, if any, better than none at all. 1st, the strain sheet must be verified; 2d, the proportioning of parts to meet the requirements determined by the specifications and strain-sheet; and 3d, an actual detailed examination of the structure from bed plates to ties and rails. On roads running frequent and heavy trains, one or more members subjected to sudden shocks, like floor-beam hangers, should be taken out, replaced by new, and tested to destruction, with a careful record kept in the

"Bridge Book." One or more of these small, easily removed members from each bridge, should be tested every year. Short riveted truss bridges should have a member of the truss taken out, replaced by a new one, and tested, once in every five (5) or ten (10) years, depending on the amount of traffic passing over it. Once in eight (8) to twelve (12) years (depending on the amount of traffic) all truss bridges under, say 150 feet span, should have a truss member removed and tested.

3. Should there not be a standard specified rolling load much heavier than as now used and a specified wheel base for rolling loads?

I think more than one standard should be prescribed to correspond with the nature of the traffic and importance of the line. It would be something of a hardship and waste to force a road running five or six trains a day, with thirty (30) ton engines, with no prospective increase either in number of trains, or weight of engines, to build such structures as would be required for another road running a great number of trains and seventy (70) or eighty (80) ton engines.

4. Is it not expedient to adopt a standard bridge floor?

It seems to me that if the width and strength of floor were specified the manner of meeting these requirements might be left to the individual designers. Guard timbers should be prescribed, one style high, for southern roads, another low for northern roads. Where snow-plows are used, they are about thirteen feet wide, having the plow proper as close to the rail as possible; consequently high guards near the rails cannot be used. In the writer's opinion, however, an iron guard railing in addition to the ordinary track guards, should be used, high enough to bear against the body of a car in the event of derailment. This guard railing could be easily braced outside, by an extension of the floor beams, and extended beyond the ends of the bridge, gradually widening so as to form a perfect protection to the structure; they could be placed wide enough apart to pass snow-plows, and yet the angle that a car could take would be slight, so there would be no possibility of going through the truss, or if a deck bridge, of going over the side. With ties laid close enough to carry a derailed truck as should certainly be the case, such accidents as have occurred during the past year, in one or two instances, would be rendered well-nigh impossible. Greased timber wales might be attached to this guard railing and some spring action provided, similar to ferry slip guard piling, to take up any possible shocks.

5. Should not bridges of small span be made strong enough for a buckle-plate floor, etc.?

Yes; but I am not prepared to say up to what span. To 6 and 7 I would say yes, in capital letters.

As to question 8, legislation seems to me to be desirable as being probably the surest way of enforcing necessary safeguards; it is, however, a technical question and the proper requirements can only be

properly specified by technical men. To that end it would seem eminently proper for the leading engineering society of the country to adopt a series of "suggestions" which should by act of legislature, become specifications, with, at the same time, power given to the Railroad Commissioners to enforce the same; penalties for non-compliance with the act to also be incorporated with it.

Bridge inspections are altogether too liable to be made in a purely perfunctory manner. Sometimes those in authority over the engineer are exceedingly chary of granting requisitions for repairs of structures; if weakness is suspected no aid is given to prove the case one way or the other, but arguments are brought forward to disabuse the engineer's mind of its "scare;" therefore an engineer should not only be allowed to make his examination as carefully as possible, even to taking out members for test, but he should be compelled by law to do so. When railway managers find their engineer is obliged to report the exact condition of each structure in writing, over his own signature, not only to the company, but also to the State, they will know in case of accident just where the blame should lie, and engineers with rather weak spinal columns, afraid to come out boldly and say "this is unsafe, I will not be responsible for it," will find their vertebræ very materially strengthened by such a law.

ROBERT A. SHAILER, M. Am. Soc. C. E.—My experience has taught me that the many damaging abuses to the parts comprising an iron or steel bridge, such as severe drifting of holes, bending plates cold, etc., are far more likely to arise during the erection of a structure than while the same is being fabricated in any of our reputable bridge works; and I therefore desire to emphasize the fact, that not only in the shops and after erection is inspection necessary, but also during the process of erection.

There seems to be no inspector present to speak for that useful branch of our profession, so in their cause I will remark that inspectors are but human beings, and therefore cannot be relied upon to be in more than one place at a time, or to see things not visible to the naked eye.

Granted that we have a good and faithful inspector, those of us who design bridges must not try to sail too close to the wind, so to speak, in the matter of details, but must be sure to have them strong enough, especially in all field connections, even if the bearing surfaces are not perfect, or there are a few loose rivets, or any other defects creep in which the inspector has not discovered or has been unable to prevent or rectify.

Guard rails on a bridge are useful for two purposes: first, to keep derailed wheels close to the rail and thus prevent the trucks from slewing round; and second, to keep the ties from bunching when a derailed train is pounding over them.

The distance between the edge of the guard and track rails should be just sufficient to allow a driving wheel of a locomotive to drop down between the two said rails. Ordinary old rails placed, say 10 inches inside of track rails, and carried two or three hundred feet beyond the ends of the truss bridges, and there brought together to a point at the center of track, will fulfill the first purpose of a guard rail admirably; and a 10 x 10 or 12 x 12 inch timber notched over the ties at or near their ends, will prevent the latter bunching, and if said timbers are well bolted will serve as an extra safety stringer. 6 x 8 strips notched into the ties and placed 10 inches outside of the track rails will be cheaper than above and will answer both purposes.

If the trucks of a car get slewed, so as to cause the wheels to mount and jump over guard rails placed as above, nothing short of a miracle will save the truss from being wrecked.

W. A. HAVEN, M. Am. Soc. C. E.—The inspection and maintenance of railroad structures is a subject on which I have maintained opinions, and I should have liked to be present at the discussion by the Convention, or to have sent you some of my views in writing, but you know I am not yet able to sit up long enough to write a page. These are very important matters, and I hope a good committee will be appointed to get the opinions of the members of the Society. I will try to send them my ideas. I will only in this place say that the American Society of Civil Engineers, should not allow that there is a standard of goodness (except the Anglo-Saxon's weights and measures), and the very idea of uniformity in railroad structures is a step backward.

One thing however I would say, viz.: Suggestion No. 6 is good and there are some contrivances equally as good, say the Latimer guard combined with the Erie Railroad shunt system, and posts at end of bridges, should be recommended for all bridges over 30-feet span.

J. M. GOODWIN, M. Am. Soc. C. E.—Any inspection of a bridge, or like structure, made by a person of fair intelligence and capacity for observation, intending to ascertain the existing facts in the matter of the physical condition of such structure, with the purpose of reporting the results of his inspection, will be measurably useful; now and again an inspection, merely superficial, will opportunely discover conditions, a continuance of which even for a few hours beyond the moment of observation would result in disaster. And one may properly agree that perfunctory "inspections," made by employees of a railway company or by State officials or their employees, have some elements of value. But a periodic inspection of the bridges of a railway, or of the railway bridges of a State, as such operation is ordinarily performed, is hardly

anything more than a ceremonious observance of some loosely constructed mandatory clause of a statute. And such "inspection" may be worse than useless in its results, as it would be in any case where an inspector should fail to condemn an insecure bridge.

The Ashtabula Bridge was "inspected" periodically from the time of its erection up to the time of its collapse. The inspector was thorough in his examination: he regularly went through the bridge (double-track deck bridge), and saw every part of it; but at every such inspection he looked with unappreciating eyes at conditions, the sight of which, had he possessed the knowledge of a bridge specialist of the present day, would have induced him to first get himself carefully out of the bridge, and to immediately thereafter cause suspension of all traffic over the structure.

This inspector regularly reported the bridge "all right," or to speak more exactly did not report it as in any way "wrong;" and the railway company, relying on the care and intelligence of a man of proved faithfulness, and general efficiency as a boss carpenter, had no doubts as to the sufficiency of the bridge. Now the inspection performed in this case was quite critical in comparison with that ordinarily given, even at this late day, by persons going through the form of inspection to satisfy the letter of some "law."

Doubtless in some cases, and perhaps in many cases, the person employed by a State Board to inspect the railway bridges of its State, is entirely competent to conduct a proper inspection of any ordinary railway bridge; but under current practice merely cursory or superficial inspections are in such cases made. The operation of looking at a bridge from the rear platform of a car running over such bridge, may be held to be a "cursory" inspection; and any inspection which does not go beyond looking at a thing is "superficial" according to the intent of my nomenclature.

In answer to the question "What is proper bridge inspection?" one may broadly say it is an inspection through which the elements, material and structural, and the physical condition of the bridge inspected are developed and set forth, by description and diagram respectively, in a report explicitly and exactly treating each and every fact and detail of consequence in the matters under examination. For a plan or scheme according to which such inspection may best be made we should apply to the bridge specialists as best qualified to supply such plan. But let the plan include the making of a plain statement, in the nature of a deduction from the ascertained facts in the case, wherein the inspector shall, under pledge of his honor and professional reputation, judge the bridge; and shall say, explicitly, all that in view of the ascertained facts he ought to say.

If the several societies of civil engineers of America will, by a congress of delegates, instructed for the purpose, formulate a scheme for

inspection of railway bridges; and if the profession, as a body, will thereafter discountenance the employment, by railroad companies or by State authorities, for the making of inspections, of persons not engineers of standing and proved ability, proper inspections of railway bridges will quite promptly follow.

But no inspection of a railway bridge made by a person who will be, however remotely, adversely affected by a condemnation or unfavorable criticism of the structure, will be accepted by the public as a thoroughly "proper" inspection. Hence, inspections of the kind herein considered, *i. e.*: those made for the purpose of securing proper construction and maintenance of public highways, are properly to be made by judiciously selected agents of the public.

Question 3 of the circular is hardly to be answered by a bare "yes" or "no;" nor could one venture to answer except after a statement of his view of the several and various existing conditions necessarily to be considered in order to the forming of an intelligent opinion in the matter. Hence, as time does not serve, I pass this query.

In regard to bridge floors I am of opinion that every railway bridge should be floored so that a locomotive may smoothly travel on the floor, from end to end of the bridge; such floor need be no more than two feet wider than the gauge of the track; it should have a high and very stout guard rail (angle-iron on timber, or an equivalent arrangement) on each edge of it. These guard rails should extend for some distance outward from each end of the bridge, flaring out from the rail so as to catch and lead toward the rail any derailed wheel encountering either of them.

Every "opening," however narrow, should be provided with similar safeguards. With these in use the suggested "continuous coat of ballast" carried by "plate floor," across minor openings, will be unnecessary.

Question 6. The "Latimer" replacer has in several notable instances, of record, saved trains, and bridges, from wreck. This very effective apparatus for replacing on the rail derailed wheels, should be set in each approach to every bridge.

Question 7. Where one railway crosses another at grade means should be used for positively preventing "crossing-collisions." Use of "interlocking" apparatus, in connection with derailing, or diverting switches, is certainly effective in this regard, and should be universal.

Question 8. As to legislation as a means for bringing about desirable reforms and improvements in railway practice and appliances: The instances in which legislation, had with the purpose indicated, has worked more harm than good, are very much more numerous than those in which the opposite effect has been noted. Guided by common law, courts decree that railroads must employ, in the service of the public,

of all devices known, those which have approved themselves to be the best; failing to do that they must make good all damage sustained in consequence of such failure, as far as money can make such damage good. A statute might say that a certain contrivance is better than any other of its class. But that would not bar evidence, on occasion, showing that such contrivance is not as good as some other well-known appliance. The statute cannot hold against the common law.

I see no necessity for special legislation in behalf of the objects under consideration.

Question 9. I think that the Society will do well to cause the appointment of a committee of its members to prepare a set of resolutions intended to serve as a presentation of the sense of the Society in the matter of inspection of railway bridges. These resolutions to be submitted to members, by circular, with request for comments and suggestions. The committee then to revise the resolutions, and, if cause appear, amend them. The adoption of the resolutions to be then put to vote by letter-ballot; and if a majority of members be in favor of adoption, the resolutions adopted to be declared as setting forth the sense of the Society. Following this the resolutions would be submitted to sister societies for concurrent action. If this be secured, the co-operating societies to proceed in the inspection affair together. Otherwise the American Society to stand to the front alone.

ALBERT LUCIUS, M. Am. Soc. C. E.—Herewith I beg you to find briefly my answers to the questions contained in the circular headed "Suggestions," as follows, viz.:

1. Hold the railway companies strictly accountable for accidents caused by failure of railway bridges on their lines.

2. I hold proper bridge inspection to consist in the examination of all parts of a bridge with the thorough knowledge of the stresses which each member of the bridge has to sustain. I would consider it necessary to have a correct strain sheet of the bridge before examination and to weed out all overstrained details and members even though they do not yet show a positive defect.

3. The specification of stresses to be borne by the various members and the rolling loads constituting the loading of a bridge must be considered together. If the various members of a bridge are proportioned by the stresses prescribed in the "Erie specifications," or specifications based upon it, the train loads specified therein I hold to be sufficient if they are preceded by a heavy load consisting of one consolidation engine and the latter preceded by a yard engine of 48 tons on a wheel base of 12 feet. This would insure heavy bridges for small openings on which the influence of the impact of the moving load is greatest, and it

would insure heavy floors, floor details and counters of long span bridges without increasing the chord members of long spans unnecessarily.

4. I would consider it expedient only to adopt a general diagram establishing general proportions, but not bind all details by fixed rules.

5. I would prefer a floor of closely laid iron ties on iron stringers, the latter spaced sufficiently far apart to give the floor a certain small amount of elasticity, to a floor made of buckle plates and ballasted as I think the latter retains moisture too long, assists corrosion and makes inspection and repairs more difficult.

6. I would favor the use of Latimer guards on all through bridges and on all trestle works and deck bridges with intermediate and battering pins which would be broken down by a train falling over the sides. Their use on other deck bridges would not be material to the safety of the bridge, but as regards the safety of the train I would favor their use on all deck bridges, their approaches and on embankments especially if the latter are on curve. All deck-bridge floors should be of same width as embankments. The end posts of through bridges might be additionally protected by posts planted in front of the end posts and braced back on the bed plates of the bridges. This might prevent some accidents caused by shifted loads or a trailing car, in other cases though, it would probably not prevent a wreck.

7. There is such a wide range in the importance and location of crossings that I would not know how to cover the whole case by one specification. I would consider it highly desirable, though, to restrict the multiplication of grade crossings both of highways and railways, and also to offer legislative inducements to reduce the number of the present grade crossings according to the importance of the case. By legislative inducements in this connection, I mean that negatively—stoppage of trains or reduced speed over grade crossings, might be enforced.

8. I would answer the same as 1.

9. I believe that the result of the deliberations of a large committee selected to prepare a report on the subject matter of the above suggestions of your circular would be beneficent, especially if it confined its labors to the preparation of a general standard specification both as regards loads and stresses by which bridges and their members shall be proportioned without prescribing too closely either the form of structure or the limits to which different forms and styles of girders or trusses shall be used in order to leave some room to the skill and individuality of the designer.

E. P. DAWLEY, M. Am. Soc. C. E.—The subject of inspection of railway bridges is of great interest to all of us, and especially to such as are responsible for their care. Answering circular headed "Suggestions," the writer would present opinions about as follows, but while expressing

such opinions, would say that he should consider it a very valuable contribution towards the welfare of the general public and a great aid to engineers of maintenance of way on our various railroads if our Society would put forward with their recommendation some standard for rolling load, and also agree generally upon preferred types of bridges, and further, a general outline of rules to be observed in maintenance of railway bridges.

This would be likely to result in a certain general standard of excellence in these respects which public opinion would cause most railroads to accept, and at same time individuals would be at liberty to exceed such standards of strength and methods of cars to any extent that might seem desirable to themselves.

1. That strain sheets of all bridges, railway, highway and others, be required to be filed with proper State authority (railroad commission if that should seem best). If railroad commission is not made the depository for everything of this kind, then a duplicate set of such bridges as are maintained by railroad companies to be deposited with railroad commission. Authority to be given to railroad commission to cause bridges to be strengthened if they deem it necessary.

But I do not think that legislative measures should go so far as to tend to make railroad officials look for or wait for, notice of defects from any State or other authority. In other words, the State supervision should always remain quite general in its nature, and the direct responsibility be, and remain with the railroad companies, where it belongs.

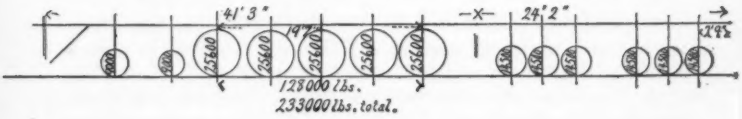
2. A proper inspection of bridges originally first class and at present (so far as strain sheet and sections go) ample for their loads would seem to the writer to be covered by the following—a thorough and minute inspection of every part and piece of the bridge to ascertain, as far as may be done by the eye and the hand and by the ear, the condition and adjustment of each piece in the bridge. To include a very careful search for loose rivets.

Measurements of vertical and lateral deflection and measurements to detect any movement of the bridge on its foundations might be included. Such an inspection to be made once in four months. Between times, an inspection more or less irregular to be made not more than a month apart, sufficiently close to know that everything is in place and in good order so far as can be readily seen. The more important parts at such a time, of course, receiving more careful consideration. The first inspection described might be illustrated by saying that it would probably consume one-quarter to one-half a day or even a day for, say a double track through bridge of 100 to 150 feet span, for engineer and assistant.

The more casual inspection might take an hour.

3. It is doubtless pretty well agreed among engineers that 3 000 pounds per lineal foot of track is not sufficiently heavy for spans 100 feet and less; that is, not sufficiently heavy to discount future service.

This railroad—the New York, Providence and Boston—has used for several years past for rolling load a wheel diagram like cut below followed by a rolling load of 3,000 pounds per lineal foot of each track, the dead load for floor being 500 pounds per lineal foot of each track.



I think it simpler, however, and full as good, say for plate girders of 75 feet span and under, to use 5,000 pounds per lineal foot of each track for live load.

Strains allowed about the same as Erie specifications.

4. About standard floor. It is to be presumed that most roads already have a standard floor of their own, and so long as they are good floors I see no great benefit to be derived from having bridge floors on different roads just alike. The writer considers the following to be a good floor, and uses it for standard: Hard pine timbers 8 x 9 inches and 26 feet long, supported below, in case of a through bridge, by seven stringers, for double track, timbers being laid flatwise, 15 inches center to center.

A guard timber, 8 x 9 inches, outside of each track, and a third one half-way between tracks which are 13 feet centers.

Guard rails running to a point in center of each track are used and continued across the bridge 7 inches from main rail. Floor timbers to be carried out on to the ground, and guard timbers to be made flaring at ends of bridge, as per Child's arrangement for the Latimer safety guard.

5. Am not yet worked up to the idea of buckle-plate floor, as it takes up height (in many places so valuable), and increases difficulty of inspection, etc.

6. Don't know much about the Latimer safety guards, and rather object to rails being continued across bridges only 2 or 3 inches away from main rail; but think the principle a good one of using the guard rails running to a point, and have so used them for some years.

7. Should be one of the two, and the overhead crossing is far ahead of the interlocking apparatus.

8. Think that legislation enforcing, say at least the standard of strength and methods of inspection which might be put forward by a society like the American Society of Civil Engineers, would be a good thing for all parties.

I believe that overhead crossings or the interlocking apparatus should be strictly enforced by law.

I have written at some length and hope you will hear similarly from others. It is the writer's conviction that in a few years from present time our largest ideas of what is required for strength and safety will be considered meager and illiberal for increasing service.

C. A. MARSHALL, M. Am. Soc. C. E.—Relating to inspection and maintenance of railway structures, I have the following to offer in response to some of the suggestions forwarded:

1. First, legislation requisite is national. The primary inspection of materials and workmanship is of the greatest importance in any individual case, and should be compulsory, and, in some few particulars, standard for the whole country. Design and execution should remain in the hands of engineers and builders as now.

There should be a commission of engineers and experts in building materials appointed annually with some holding over members, for the purpose of examining inspectors and issuing licenses, or these duties might be well incorporated with those of the proposed commission on structural materials. The duties of inspectors to be defined by this commission in accordance with legislation. The commission to receive compensation and to sit for examinations simultaneously in several large cities by division of members.

There should be licenses of three different grades:

First.—As to materials.

Second.—As to fabrication.

Third.—As to compliance with general strength and safety requirements (apart from materials and shop workmanship) which may be set by the commission.

An inspector certifying to any of above three kinds of inspection must make oath that he is not in the pay of, nor pecuniarily interested with, case 1st. The manufacturers or sellers of the material; case 2d. The builders or contractors; case 3d. Either or any of them.

Engineers may become inspectors, but may not deputize the work to unlicensed men; the form of oath should prevent this. It would probably be expedient to arrange for licenses of the third class being taken out by practicing engineers upon satisfactory evidence of competency other than personal examination.

There should be stated maximum fees for inspection of different classes of work. A licensed inspector in the nearest town may not refuse to take work at the regular price—plus mileage, but may take work wherever he can get it, and at lower prices, if he choose. The number of inspectors in a given territory should not be limited, but each must designate some locality, as headquarters.

Inspectors should pay a moderate annual license fee, and it should be made a penal offense after a certain lapse of time to build certain

classes of structures without securing the services of a licensed inspector or inspectors. This the general government can control as well as it now does steamboat boilers, and the inspectors themselves will be active to see that all cases are reported.

There should be a salaried chief inspector, having power to suspend, and two or three deputies to assist him in settling disputes and enforcing regulations, especially the requirement of personal attention to the work.

Builders to be required by law to furnish the inspector, free of charge, besides the usual information, a complete copy of strain sheets and detail drawings, giving full and exact information of all bridge work inspected by him, for which he shall furnish receipt in duplicate, and he shall certify that they correctly represent the work inspected, and further that the requirements of the commission as to workmanship have been complied with. Inspector also to certify under a copy of the specifications for material that they are complied with, including also any requirements of the commission, and give particulars as to where, when and by whom made.

Certificate of an inspector of the third class as to strength and safety shall be obtained by the owner of the structure within a certain time after completion. All the information and certificates to be lodged with a designated officer of the State in which structure is located, and for their own protection the builders shall lodge an inspector's receipt with the chief inspector.

To the State must be left the inspection of completed structures. They may give the work to a Department of Public Safety or a Commission, as seems wise. There is no question but the work should be done and the States should be urged by the National Commission and by all possible means to provide for efficient record-keeping and inspection of structures located within their borders. They should designate an officer to receive the reports of the licensed inspectors of new structures and should provide a sufficient force of experts to thoroughly and systematically inspect. The force needed would be greatest at the start, and much less when good records had been secured and bad structures weeded out.

The National Commission should provide a system of registration and grading of condition of structures including recommended forms of blanks, but must confine themselves to recommendations in this branch of the subject having due regard to work already begun.

2. Proper bridge inspection presupposes good records either at hand or to be made at the time. It should be systematic, but no amount of system can take the place of actual personal inspection by a competent expert in both theory and practice of bridge building.

3. The question of rolling load is overshadowed by that of impact effect. It would be idle to specify heavy loads without at the same time

limiting unit stresses. Think that floor system should be designed for heavier loads than now, and that it would be proper subject for recommendation by committee, but not for legislation for some time yet.

4, 5 and 6. A standard minimum actual weight of floor system would be a good thing on all bridges of less than 150 feet-span, which from 150 feet to 75 feet need not be so heavy as the buckle plate and ballast, below 75 feet should be as heavy as that. Both inside safety guards and outside guards should be required by law; also standard for opening between ties at, say, 4 or 5 inches. In case of deck plate, web or solid girder bridges only, the whole bridge might be considered as floor system. Inside safety guards when bridge is approached on curve should be repeated or extended well back on the curve. I once investigated a fallen truss bridge which proved to have been knocked down by a blow of the corner of a freight car on the end post; two cars had been off the track some two hundred yards back on a curve without the engineer's knowledge. The engine and two cars crossed the span in safety, and the remainder of the train was wrecked. Safety guards terminating near end of bridge would not have saved it, though my remembrance is, none were used. The inside wheel of the car was nearer the outer rail than the inner one when it struck the bridge.

8. I regard the plan detailed in (1) as most expedient and pressing in order to further uniformity and safety in these matters. The dangers to the average bridge of the country are perhaps as great from faulty design as from trains off the track, while to a well-designed bridge the latter constitutes, by far, the chief source of danger. To weed out the weak existing bridges the legislation should be by the State. To guard all bridges existing and to be built against trains off the track, as far as possible to do so, is also in the province of the State, but would be better done in accordance with a standard mode. To set a few necessary standards in this and other particulars should be the work of a national commission, and to bring about such a commission, as well as to influence corporations in the right direction, is a proper task for this Society.

DISCUSSION AT CONVENTION.

D. J. WHITTEMORE, Past President Am. Soc. C. E.—Mr. Chairman and Members of the American Society of Civil Engineers: Twenty-two years ago I was appointed chief engineer of a company having a line of railway which was then 275 miles long. The company was then in nearly a bankrupt condition, and through decay and use the greater portion of its structures of a perishable nature had to be replaced, and it was a difficult matter to determine how to plan the work of repairs and renewals, and have the expense of the same within the means of the company with due regard to the safety of the public. This, however, was accomplished, and within the last twenty-two years this company has built 2 700 miles of road and acquired by purchase other lines, which bring its mileage up to 5 400 miles at this date. This rapid increase of mileage, involving, as it did, great responsibility on the part of the engineer in the inspection of bridges, impressed upon him the necessity of formulating a complete system, so far as he could devise it, of tests and inspection. The magnitude of the work at once suggested the making and adopting of standard plans of structures. These were made, and after conforming to them for about one year it was found necessary to change nearly all to meet the requirements of increased rolling loads, and I may say that this process has continued and probably will continue to the end. I find that on the system of railway with which I am connected, two per cent. of its length is covered by bridges consisting of spans of from 10 to 400 feet, and generalizing from this I conclude that there are some 2 800 miles of bridging on the 140 000 miles of railway now in this country. It appears to me that the members of this Society cannot do a better service to our profession than to recommend a proper system for bridge inspection. About one-tenth of the bridges upon our line are iron and the balance are of wood. We endeavor to have a skillful inspector, one skilled in bridge construction examine every structure at least twice each year, and this inspection is not construed as in any way relieving bridge carpenters, road masters and section foremen from making periodic examination and inspection of the same structures. Plans of every structure, including culverts, are on record in the engineer department. All bridges are designated by even numbers and culverts by the odd numbers. Each division superintendent is furnished a book giving the general dimensions and number of bridges and culverts on his division. The general superintendent and general manager have a book of the same kind. A book account is opened in the engineer department with each structure, in which is entered the date of inspection, repairs required, date when repairs are made, and the cost of same. The division foremen are required to state at the end of each month what has been done in making such repairs, so that in the end we have positive knowledge of when every stick

of timber or other material is placed in the structure. This you will observe requires a deal of clerical work besides that of inspection; and I was somewhat amused at receiving a request from a railway commissioner of one of the States through which our line passes, for a copy of all our reports of the inspection of bridges. I hardly need to say that we did not send them; we could not see that a carload of records for the use of a State railway commissioner would be of any service either to him or to us. Under this system of inspection it is gratifying to state that our line has been operated for twenty-two years without the failure of a single structure under normal conditions of traffic. If there is any class of persons that I do love, it is the average railway commissioner, appointed either by the governors of the different States or through political influence. If it is correct policy for States to appoint inspectors of railway structures and require the railway companies to conform to their demands, then it is but fair that the State be held responsible for any failure. I cannot believe that any State can be found willing to assume this responsibility and I do assume that no railway company will accept the inspection of a political officer, but will depend upon the inspection of those they believe to be their own tried and faithful servants. I believe in proper legislation that will require periodic inspection by competent persons appointed by the railway companies, and, in case of failure, hold, as the law does hold, the company responsible for any damage that occurs through fault of its own. Perhaps I have been more fortunate than many of my professional brethren. I have yet to find the manager of a line of railway who had been informed by the engineer that a structure was unsafe who did not immediately say, Make it safe at once.

THEODORE COOPER, M. Am. Soc. C. E.—The question of the best method of securing a proper inspection of bridges is a very important one.

A bridge is a machine, and the man who inspects it must know what that machine is intended to do and whether it is in a condition to do it safely. It is not simply a question of the material of which it is made or of any individual member, but of each and every member individually and collectively.

Great stress is made in many cases of testing the iron or steel of which a structure is made, and but little attention paid to the design, proportion or assemblage of the parts.

Of course I do not mean to decry the testing of the material, but I do not recall at present a single case where a bridge has fallen solely because the material was poor.

The majority of failures have been due to bad design, bad workmanship or neglect to keep the structure in a proper condition to do its duty.

A bridge inspector must be an all-round man, sufficiently acquainted with the question of strains and theory of the action of each part of the structures under the varying conditions of the loads, with practical knowledge of the workmanship of the various kinds which enter into bridge construction, possessing an observing eye and a cultivated sense of feeling, and practical common sense, in order to determine whether a structure is doing its work satisfactorily and safely. He must take up each structure as a special problem and examine each member and each joint to see if it is in proper condition to do its full duty. He must not depend upon the office plans or upon the strain sheets. I have had to condemn bridges as dangerous after a field examination, that appeared perfectly satisfactory from the office plans. I might give many instances, but will mention only two. One was due to a change in the form of the castings, the webs taking the main part of the load being misplaced by the foundry man, so the castings were sheared through and the bridge on the point of collapse. In another case, only discovered by the merest accident, I found that the hanger of the end floor beam of a long span was carrying the same load as the end main diagonals, three panel loads, through the shop error of the pin hole being bored one-quarter inch larger than the pin.

We hear a good deal about defective rivets, and I have known structures where the rivets in certain parts were constantly being renewed. Many inspectors consider their duty done when bad rivets are cut out and new ones put in. But they should go further and determine why these rivets constantly work loose, and apply the remedy.

Soon after the Bussey bridge disaster I read in the papers that the railroad commission in one or more of the States had ordered all bridges tested for deflection to determine if they were safe.

Such inspection does more harm than good. Nothing in regard to the strength of a bridge can be determined by the deflection. The deflection of a bridge is simply the summation of the relative action of the several parts of the structure, good, bad and indifferent. Any one of dozens of the members may be at a point of absolute rupture without producing any appreciable change in the deflection.

How could the deflection of the Bussey bridge determine that the floor beam hangers were actually half broken and dangerous?

As to the subject of legislation, I do not think any law could be framed which would accomplish the purpose by defining the character or time of inspection. Neither do I believe any good would be gained by having the inspection made by a State expert. How would you define an expert? What is to-day the legal definition of an engineer? And even assume that the best bridge man of the day was made this expert, how long would it be before he would become an old fogy and oppose all progress beyond the stage of the art as he left it? No, we have not

yet learned all that is to be learned in any branch of science, and it is not according to American instincts to cease advancing and be bound to the dictum of any one man. Railroad bridges are not the only bridges where proper care and inspection are needed to protect life and property. Our cities, towns and counties have dangerous bridges. I know of bridges in one of our large cities that are so grossly neglected that if not now dangerous, they are rapidly becoming so.

There is, to my mind, only one way to apply a remedy. Let the law clearly and definitely make the officials of our railroads, cities and counties criminally responsible for loss or injury to life, commencing at the top and working down through the necessary organization until each stage of the organization can show that proper methods have been taken to know the condition of each structure at all times and that the power and means have been given to put and keep the same in a safe condition.

If a bridge goes down because the officials preferred not to know officially its dangerous condition, or if knowing, they neglected to remedy it, the criminal responsibility should be placed upon them.

If through a bad organization or false economy the overworked switchman, operator or despatcher produced a collision, the criminal responsibility should be on the officials to whom the bad organization or false ecomony is due and not on the man who has tried to do more than nature would permit.

Financial responsibility may be powerful enough in many cases, but it will not cover that large class of roads which have no owners, the football of Wall street—roads which are managed by men who have only a temporary interest in the same—roads whose officials have no higher aim than a good showing for the existing year or quarter, and who are willing to obtain such favorable temporary reports at the greatest hazards. Such roads will not spend money in a proper organization or for strengthening weak bridges. Criminal responsibility only can reach such officials.

Now, I am perfectly conscious of the vastness of a railroad organization, and that it is impossible for the directors or the operating officials to know, of personal knowledge, all the details of the different departments of their road. But it is their duty to know that each department is in charge of a competent specialist; to furnish him the men and means to perform his duties; and to know through proper system that his department is in good condition for a safe service.

Any attempt to establish a standard for the strength of bridges would be injudicious and impolitic. We will all agree that it is desirable that our bridges be built strong enough for any possible future traffic, and we also know that an increased capacity will not increase the cost anything like in proportion. But many well-managed, but financially poor roads cannot bear even this moderate increase in expenditure.

While it is their duty to the public to maintain their structures in a safe condition, it would not be right to compel them in their struggle for existence to do more than this. It is our duty as engineers to give them safe structures, and after that the best we can for their money. For roads capable of bearing the expense I would always recommend the best structures as the most economical in time, but for roads with short purses I would strive to give them perfectly safe structures and the best that their means would afford.

In regard to bridge floors, I cannot see any merit in a buckle-plate floor.

The floor of a bridge is the most important part of the structure and I favor a very heavy floor system. I believe in putting plenty of timber on that floor and substantial outside wooden guard rails as close to the rails as possible and as high as the rolling stock will permit.

If the sustaining members of the floor, stringers and cross floor beams are sufficiently strong, I do not see where the buckle plates will have any advantage over a good close timber floor, and if these sustaining members are not strong enough I do not see that the buckle plates will help the matter.

In addition to the wooden outside guard rails, which should never be omitted, an inside guard rail is also very desirable. Theoretically the inside guard rail is the better of the two, where both are of the same height. Unfortunately the inside guard rail must generally be limited to the height of the rails, which reduces its value very much, when acting alone.

The purpose of a guard rail being twofold, first to catch a derailed truck as soon as possible and prevent its slewing, and second to protect the trusses of a bridge from being struck by any part of the rolling stock, it is desirable that they be placed as near as possible to the rails. To prevent the wheels working up these guards, and surmounting them, it is desirable to have them as high as possible. I have seen on a guard rail, about 7 inches high, the marks of a derailed wheel, which was safely carried across the bridge, but which was continuously mounting nearly to its top by the friction.

The greatest obstacle to placing a guard rail 8 to 9 inches high, within less than 18 inches of the rail is the snow-plow.

There are plenty of bridges where the guard rails are placed so far out, in order to clear the snow-plows, that they serve no good purpose to either catch the truck before it slews to a dangerous extent, or to prevent the cars striking the trusses. Now, the snow-plow is a very necessary implement, but that the safety of so many bridges should be uninsured through neglect to make these snow-plows capable of passing automatically over the guard rails of bridges is a matter of astonishment. I would be surprised at any master mechanic who would state that snow-plows could not be made to automatically lift over such guard rails, at

a very moderate expenditure compared to the risks now incurred by rendering useless the guards over so many of our bridges.

I will finish by taking exception to a remark that has been made, comparing this Society, as regards establishing standards, to the Society of Master Car Builders; the case is not similar. The Society of Master Car Builders is composed of men who are devoted to the one subject of car building, and are therefore competent to consider and decide upon any matters pertaining to this business. Now, while we are all civil engineers in the broad sense of that title, our practice and experience are widely diversified, and we really belong to widely different professions. There are in this room electrical, hydraulic, mechanical, municipal, railroad and other special classes of engineers. Are the electrical or hydraulic engineers competent, as a class, to decide upon matters or standards for railroad purposes, or is the railroad engineer competent to determine standards for electrical purposes?

No, this society, as a body, is not competent to decide upon matters relating to any specialty.

I do not therefore consider it competent to establish standards upon bridge matters. Let us have full and free discussions upon all matters pertaining to the broad profession of the civil engineer, but leave the detail to those among us who are specially devoted to each subordinate branch.

H. STANLEY GOODWIN, M. Am. Soc. C. E.—Mr. Chairman, I think that almost everything I would say has been well said by those who have preceded me. I will say, however, that I agree with Mr. Wilson's plan and approve his suggestions. His plan of classification by numbers is certainly a most admirable one.

I think the schemes of legislation spoken of are impracticable, and some of them may, with propriety, be called Utopian. It has been stated that there are in the State of Michigan some 6 000 bridges; how is one engineer to look after the details of those 6 000 bridges? And if Congress is to take up this matter how is Congress to look after intelligently and practically, the construction and maintenance of 2 500 miles of bridges? It seems to me quite impracticable. Suppose it were to happen that all the bridges in the State of Michigan, or in the United States were to come under the control of one corporation, how would that corporation manage to care for these bridges? Why, simply in some such way as Mr. Wilson suggests. But one general head or superintendent could not give his attention to the investigation in detail, because there would be too many bridges. He would probably district the States under his supervision, and appoint to each district enough inspectors to insure thorough inspection and reports of all the bridges in that district. For the State to undertake to do all this, or to do such part of it as would be of use to the public, would seem to me going

beyond the authority which ought to be vested in State Government. I think that the success of the railroad corporations and of all branches of business in the country, is due to the fact that they are managed and governed by the interests in whose ownership they are, and not by State interference, and I think it would be desirable that the present state of affairs should continue. I do think, however, that there could be such a change in legislation as would prescribe what the railroad companies should do in the way of inspection of their bridges, and specifying that the companies should have such reports made to them that they would know their bridges to be sufficiently strong to carry the tonnage and loads that were passing over them. I do not think any railroad company would object to that.

There are a good many other points brought out by the circular. One is, and a good one, that this idea of inspection of bridges ought to include the turnpike and wagon road bridges. If Government interference is going to take hold at all, it should take hold of these. The public have to drive and walk over them, and they generally receive very little inspection, while railroad bridges are subject to an inspection more or less complete.

In regard to a standard bridge floor it does not seem to me practicable to adopt a standard form, because there is necessarily such a great variation in the styles of bridges.

In regard to overhead crossings, if it is meant to ask whether a grade crossing now existing and which has been in use for a number of years, ought to be altered to an overhead crossing, I would say that in many places overhead crossings are almost impracticable on account of their great cost, and would be very objectionable on account of the heavy grades of the overhead road.

There are many roads with small capital which would be very much embarrassed by a law making necessary such a change at all their crossings.

A. M. WELLINGTON, M. Am. Soc. C. E.—Mr. Chairman, I have very little to say because I am not prepared to say it; the questions cover too broad a field to be all discussed together advantageously, but I must say I sympathize with what the gentlemen have said in regard to the question of legislation. I have remarked that in the written communications they have referred largely to the subject of legislation; I do not see what useful action we can take in regard to that. The only point as to which this Society should be particularly well qualified to express valuable opinions, is in specifying what are the ends to be accomplished, and that was very little touched upon in comparison to legal methods for providing a system by which bridges should be inspected. But in the other direction I think that there are strong evidences that something ought to be done, viz., in elaborating methods by which it

shall be ensured that iron bridges shall be built so strong in the first place as to be in no danger of breaking down. It seems to me that this is a far better method of insuring their safety; to build them so that they do not need to be gone over with a microscope once in six months, to prevent their giving out. Now, the fact is that nearly all our iron bridges prove worthless from having sailed too close to the wind in their design; the average life of an iron bridge is very brief; long before they are worn out they are removed because they are too weak. And moreover, I do not believe that we have reached the limit of load by any means. There are roads now that are running cars weighing 3 600 pounds to the foot, and the tendency of the introduction of train brakes will be to cause a further increase of load. In New York, for example, on the New York Central Railroad, the bridges are proportioned for light engines; they claim that they cannot use heavy engines, because with their easy grades the train becomes so long that it breaks in two, but with the introduction of automatic brakes, and with the introduction of train brakes that difficulty will be eliminated. It is only a question of a few years when those bridges will have to sustain very much heavier engine and train loads, and hence all prove worthless. I think our bridge specialists, who show such ability in design of details, do not realize the imminence of this change, and do not make sufficient efforts to provide for it in advance. I have no doubt that by the discussion in detail of these subjects which have been proposed, one by one, some very useful results may be accomplished, both in the way of economy and of improvement, but I hardly feel disposed to attempt to cover all that might be said in regard to them, or as to the numerous points in which I should differ more or less from the views so far advanced until the questions come up for discussion one by one.

PERCIVAL ROBERTS, JR., M. Am. Soc. C. E.—There has been a great deal said in regard to the inspection of bridges in use, but there is an old adage: "You must first catch your hare before you cook it," and I think the inspection should commence from the day of asking for proposals on the bridge. I think, too often that when serious interests are involved, the sum total of the dollars and cents of the estimate are more closely looked at than are the interests themselves. Not only should estimates for bridges be compared one with another, but a thorough examination of strain sheet should be made by a thoroughly competent engineer. It is not sufficient to issue proposals based on certain standard specifications, but the strain sheets of all bidders should have careful attention. Now, presuming that this is not the case, however, I think that the first inspection we should have is the shop inspection. We all know how insufficient a shop inspection often is. We are very apt to find there a gentleman who has come to inspect a certain bridge, who walks into the shop with a tack-hammer in his hand, and

for several days after that you will hear the tack-hammer going all over the shop, and possibly there may be a check mark here and there on a rivet, etc. Sometimes, when the work is over, the inspector will ask for a copy of the drawings that he will examine later. I think that we should have a rigid and intelligent inspection while the structure is passing through the shop; that is the point where we can discover any defects. I think that all manufacturers will welcome such an inspection; it is a preventive to cutting prices, and to getting out a structure which is not up to the requirements of the specifications. The railroads too frequently start at the bottom with their inspectors, and instead of having an intelligent man for an inspector he is a young fellow, fresh from college, which I think is poor economy.

Mr. WHITTEMORE.—I fear what Mr. Roberts says is too true. In this matter of inspection I freely admit that I have at several times been most grievously swindled, and I judge others have also, as for instance: About a month ago I was at a shop where an inspector was supposed to be performing his duties, and the manufacturer said to me, "I wish you to look at that fellow, he is an inspector;" he was reading a dime novel in an inner office at the shops; presently some one came in and said, "that car is loaded now," and the inspector went out to the car, looked at the scales on which it was weighed, made a memorandum and then went back to his dime novel.

Mr. P. ROBERTS, Jr.—I understand that a number of foreign shops and works employ a man whose duty it is to entertain inspectors. They are professional experts in a number of things not pertaining to bridge work; they talk professionally to the inspector, take him out to dinner, etc., and it is a very good thing indeed.

The CHAIRMAN, Mr. T. C. CLARKE.—I believe that there are several inspectors present. I certainly think that you will all agree with me that they ought to be heard from.

C. C. SCHNEIDER, M. Am. Soc. C. E.—Mr. Chairman, I would say that the best inspectors are not always the ones who are the best appreciated; sometimes the men who have the least experience get the best positions and the good men have to take a back seat.

The CHAIRMAN.—I will ask any inspector to give us his views. They would be very interesting.

C. FRANK ALLEN, M. Am. Soc. C. E.—I am not an inspector, but I will say that I fear that this matter of legislation would relieve the railroad companies of responsibility. I believe that they should be held strictly responsible, both legally and to public opinion, but I believe that a certain amount of legislation would be valuable in the direction which we are aiming at. It seems to me that legislation should require some report upon the inspection of works so that the inspec-

tions that were made should become public property; so that it should be possible, when any defect was found, to run it down and fix the responsibility upon some one, either upon the president of the road, or upon the inspector. I believe that legislation that would secure some results of that sort would be healthy legislation, and could be thoroughly indorsed. One of the valuable points would be the fixing of the responsibility; I think we could make decided gains in that way.

There is one other view of the matter which is really, perhaps, of the most importance and yet most difficult to reach, and that is, that the general managers of railroads are frequently men who have a very small opinion of the value of the services of civil engineers; with a proportion of the managers the civil engineer is simply a surveyor; a very considerable proportion of railroad managers are prejudiced against civil engineers; if it is necessary to hire one they will hire the cheapest man that will do that service. This Society could do a good work in educating a considerable portion of our railroad men as to what a civil engineer is, and as to the value of his services; that when it is necessary to employ an engineer, they should get a good one, one who will know what the expenses to be incurred may be, the injury to car wheels, etc.; if it is necessary to run out a location, they should have a man of ability and experience, so that the company will be saved some money by listening to a man who knows what he is talking about. It is necessary to educate the railroad managers to the idea that the civil engineer will save them some money; if you touch the pocket you touch a tender point.

The SECRETARY.—A gentleman has handed me a copy of the provisions of the law of the State of Massachusetts with a circular from the Board of Railroad Commissioners of that State. It is interesting in this discussion as being a requirement of the State of Massachusetts through its legislative enactment of the present year.

COMMONWEALTH OF MASSACHUSETTS,
BOARD OF RAILROAD COMMISSIONERS,
20 BEACON STREET.

BOSTON, ..., 188...

To..... .....Railroad Company.

SIR:

Your attention is called to the following sections of Chapter 334 of the Acts of the present year, being "An Act relating to the Examination of Railroad Bridges:"

SEC. 1.—Every railroad corporation shall, when requested by the railroad commissioners and at least once in two years, have an examination of its bridges and the approaches thereto made by a competent and experienced engineer, who shall report to the corporation the results of his examinations, his conclusions and recommendations, and the corporation shall forthwith transmit a copy of the report to the board of railroad commissioners. The first report shall be made and transmitted to the board not later than the first day of November, in the year eighteen hundred and eighty-seven, and subsequent reports shall be made and

transmitted at intervals of not more than two years. When a railroad corporation builds a new bridge it shall forthwith have a report in like manner made and transmitted to the board. The reports shall furnish such information in such detail and with such drawings or prints as may be in writing requested by the board of railroad commissioners.

SEC. 3.—Nothing herein contained shall be construed to exempt a corporation from making other and more frequent examinations of its bridges and the approaches thereto.

In accordance therewith, the Board of Railroad Commissioners request you to transmit to them, on or before the first day of November next, the following information, plans, etc., relating to the bridge structures on the line of your railroad and its branches, said information, etc., to be given for every bridge structure of over ten feet opening in the clear, between abutments, but not to include highway or street bridges over the road.

I. A statement, in tabular form, giving in order the following data: (1) number of bridge; (2) town in which, and (3) line upon which it is situated; (4) precise location upon the line, if on record; (5) direction and distance from, and name of nearest station; (6) ordinary name; (7) nature of crossing (stream, street, etc.); (8) number of openings, and clear span of each; (9) length over all; (10) material; (11) general style of bridge; (12) whether deck or through; (13) approximate maximum height of rail above stream, street, etc.; (14) date of erection; (15) names of designer and of builder; (16) by whom erected; (17) whether or not built to definite specifications. On this sheet shall also be stated the weights of the heaviest engines, tenders, and loaded cars at present in use on the road, specifying load on each axle, and distances apart.

This table is preferably not to be a blue print, so that additions can be made to it from time to time, and is to be on one or more sheets of uniform size. Sample sheet for the above returns can be seen at the office of the Board.

II. A "strain sheet" for each structure, giving—

(a) For frame structures, the calculated maximum stress in each piece;

(b) For plate-girders and beams (including floor beams and stringers of truss bridges), the maximum moment and shear at points not over ten feet apart, including the center and ends.

The loads to be assumed in making out the strain sheet are to be either those under IV (a), or the heaviest loads in actual use on the road—whichever cause the greatest stresses—and are to be clearly shown or stated on the strain sheet. The actual loads in use may, if desired, be considered in the calculation as replaced by a suitable uniform load headed by a suitable concentrated load.

If practicable, the information called for under IV (b), (c) and (d) shall all be given on the strain sheet.

III. Blue prints or drawings showing complete dimensions of each structure, with sections and dimensions of every part, and details of all connections or splices. Scales for drawings to be: (a) for general elevations, cross-sections and plan, not less than $\frac{1}{4}$ inch to the foot; (b) for all details of connections and splices, and sections of parts, not less than $\frac{1}{2}$ inch to the foot, and preferably not less than $\frac{3}{4}$ inch to the foot. The complete floor system is to be clearly shown on these drawings.

These sheets, together with the strain sheet and the table under I., shall be made of uniform size, 28″ × 40″, including a margin on the left hand side of 2 inches.

IV. For each bridge: (a) If built to definite specifications, a copy of such specifications, together with a statement as to the tests, superintendence, etc., by which they were enforced.

(b) If built without definite specifications, a statement of the source and quality of the material employed, whether any tests were made upon it, together with the results of such tests.

(c) A statement of the frequency with which it has been inspected, and by whom; and, so far as known, the results of any tests applied to it since its erection.

(d) If not given under (a), a statement of the loads for which it was calculated, and of the stresses allowed per square inch under different circumstances.

V. A report by a competent and experienced engineer, as required by Sec. 1 of the Act referred to above, which report shall include the results of his examinations, his conclusions and recommendations, not only in regard to the bridge structure itself, but also in regard to the approaches to the bridge, and the piers and abutments.

Plans not conforming to the above requirements, if already prepared, may be presented to the Board for approval.

GEORGE G. CROCKER,
EDWARD W. KINSLEY,
EVERETT A. STEVENS,
Commissioners.

FREDERIC GRAFF, Past President Am. Soc. C. E.—Mr. Chairman, I wish to speak of a matter which seems to me to be connected with this subject. The City of Philadelphia has been agitated frequently by the question of elevated railroads, and I would like to ask from the gentlemen here what inspections are insisted upon for the systems of elevated railroads in the City of New York?

R. I. SLOAN, M. Am. Soc. C. E.—The elevated railway structures in the City of New York were designed by careful engineers, and built and erected by responsible bridge building firms. Good iron was used in the construction, and good engineering work was done in the beginning. A large portion of the system has been in operation more than nine years, and the entire system of 32 miles over eight years, and over 12 000 000 trains have passed over the roads. The structures have been submitted to continuous use under the light rolling loads. The strains imposed upon the girders do not exceed in any case what good iron ought to stand.

The factor of safety required by the Rapid Transit Commissioners and the daily thorough inspection maintained render the structures perfectly safe.

The maintenance of the structure, track, signals and buildings is in charge of the chief engineer, his assistants, and the road master and his assistants, four supervisors, and the structure and track foreman.

Daily reports are made by the road master to the chief engineer, who reports the same day to the general manager, all defects in foundations, structure or track. We have also arranged with Mr. Albert Lucius, M. Am. Soc. C. E., an expert bridge engineer, to make frequent examinations of the structures and report to the chief engineer every two or three months.

The great increase of travel on the Third and Sixth avenue lines has made it necessary to increase the weights of the engines from 17 to 19 and 21½ tons, and to keep the factor of safety within the limit prescribed by the Rapid Transit Commissioners, we have strengthened the floor beams on the Sixth avenue, pin-connected structure and strengthened the Third avenue girders by a double system of triangulation, the braces united at their intersections. The 5 x 10 inside guard timbers have been replaced by timbers 6 x 8 inches, also an additional timber has been put alongside the outer rail, making the guard 12 x 8 inches. Fifty-pound rails are being replaced by 70-pound rails. The pounding of the rail joints has been lessened by the use of improved supports and splices. The Fisher joint has so far given very good satisfaction by presenting to the tread of the wheel, when passing from one rail to another, an even surface.

The greatest metal wear is on the steel rails of the sharp curves, those of 90-feet radius. These have to be renewed about every 18 months. The ties have shown very little decay, and have been down from eight to ten years. Many are shortened and broken up by the spikes, bolts, log screws, etc. All those taken out are replaced by ties six inches deep and eight inches wide.

Mr. GRAFF.—You are in the condition of the bridge structures, you have not reached the standard for the proper elevated road, but you are searching for it by strengthening every part?

Mr. SLOAN.—I would recommend the use of plate girders for a proper elevated road. We all know that the plate girder if properly proportioned is economical, stiff, trustworthy and requires less inspection than any other form of short span girders.

A MEMBER.—What is the size of the plate girders?

Mr. SLOAN.—Those plate girders lately put in are 39 inches deep. Top chords 6 x 6 angles, 65 pounds to the yard, web ⅜ inches. Those on the old Ninth avenue structure and in Battery Park are about 24 inches deep, but are very stiff, seldom find a loose nut.

J. FOSTER FLAGG, M. Am. Soc. C. E.—The ties are not creosoted?

Mr. SLOAN.—No, sir; three years ago we tried some which had been vulcanized.

Mr. FLAGG.—Have you tried broken-jointed rails?

Mr. SLOAN.—Yes, sir; we break the rail joints.

Mr. FLAGG.—Do you use the bevel joint?

Mr. SLOAN.—We tried the bevel joint for a short distance on the Sixth

avenue, but I would not attempt that again. I would prefer to have a square rail joint.

A MEMBER.—Do you find any defects apparent in the columns?

Mr. SLOAN.—None in the rectangular columns. We found some two years ago, during very cold weather, a few rivets had burst in some of the high Phœnix columns which were filled with cement mortar. I think it was caused by the contraction of the iron segments which form the column hugging close the rigid cement column inside. Each segment as it contracted pulled away from the others so hard as to burst the head from the rivet. I did not consider there was danger to the structure, as the surplus strength of the columns is very great.

J. J. R. CROES, M. Am. Soc. C. E.—What is the weight of the engines?

Mr. SLOAN.—From 15 to 21½ tons, according to the type.

Mr. CROES.—During the busy hours what is the interval between the trains on the Third avenue road?

Mr. SLOAN.—About two minutes, but that is at 129th street.

Speaking of grade crossings, the interlocking apparatus we use at Chatham square has demonstrated what can be done in passing trains if carefully managed. About 3 000 000 trains have passed over the crossings at this point, and there has been but one collision; that occurred last fall. A train coming from Second avenue collided with a northbound train going up Third avenue; the engine driver ran past the red or danger signal.

The CHAIRMAN.—Since you have been strengthening the Third avenue line have you seen any loosening of rivets?

Mr. SLOAN.—I have heard of none on the girders which have been reinforced. Where the structure is painted a light color a loose rivet is soon discovered by the little streak of rust which shows on the light paint.

Mr. CROES.—How long is it expected to continue the strengthening?

Mr. SLOAN.—We commenced about three years and a-half ago, and will have the Third avenue line done by next spring.

Mr. CROES.—How many trains run over the Third avenue road a day?

Mr. SLOAN.—On an average 490 going north and 490 coming south.

Mr. CROES.—I remember a few months ago there was a set of switches at South Ferry, and the man in charge said there were 2 400 trains a day passed over them.

I think if iron bridges are good for anything at all that the two lines of iron bridges in New York ought to show their defects and their merits. I do not suppose that any iron structure in the world is subjected to the tests that these are.

THEODORE COOPER, M. Am. Soc. C. E.—In a paper by Mr. Benjamin Baker, of London, an eminent engineer, upon the strength of materials

subject to alternate and repeated strains, he makes the statement that the elevated roads of New York City have developed unexpected defects due to the frequent application of the loading. There is no truth in this statement. I was connected with these roads during their early stages, and have ever since made their action a special subject of study and observation. I had nothing to do with their design or proportions, but did have an intimate knowledge of their construction.

In some cases, charter time agreements necessitated the temporary acceptance of imperfect work. This was one cause of the renewal of certain portions. Another was the unexpected development of the traffic. Locomotives capable of handling two cars were supposed to be ample, whereas now trains of five cars are inadequate to satisfy the demands. To provide for this, much increased strength has had to be provided. We can also say from our present knowledge of the duties to be performed by these roads, that the design is not the best.

There have, however, been no defects developed in these structures which cannot be clearly traced to faulty design, hasty workmanship or want of appreciation of the traffic demands. And not a bit of evidence can be found to show that the rapidity or number of trains have developed defects that would not in time have been produced under other conditions of the same loads.

I do not believe that any number of applications of the loading will produce any more injury than a single loading upon a structure so proportioned that the actual strains shall never exceed the elastic capacity of the material. There is no reason why an elevated railroad cannot be designed and constructed to be as permanent as any other structure made by man, and as safe as any other system of railroad.

Mr. WILLIAM KENT.—I am not a bridge expert, nor a member of this Society, but, through the courtesy extended to the American Society of Mechanical Engineers, am attending your convention.

In regard to the competency of this Society to pass upon the question as to what legal measures should be taken, one gentleman says this Society is not competent because it contains several professions. There is no Society to-day especially devoted to bridges. This Society certainly contains within itself all the best bridge talent of the country, and if they are only five, I say this question of bridges had better be referred to them for discussion. The work done recently by the American Society of Mechanical Engineers on the question of standard steam boilers and trials of standard pipe threads was this: the Society appointed two committees, one of boiler experts and one on pipe threads. The boiler report was submitted and discussed, and when it came up finally before the Society they recommended that it should be printed by the Society; after a very lengthy discussion, two years ago, it was decided that the Society should indorse no report and should take no action

whatever, but that they would publish this report with the names of the committee attached. It was the general opinion that the report would have more weight than a mere vote of the whole Society. When the question of pipe threads came up it was again decided that the Society would not adopt the report, but would publish it. Now all the steam-users are adopting it and it is going to be the standard of this country.

Applying this argument to the bridge question, I say that this whole subject of what measures, legal or other, can be taken had better be referred by the Society to a committee of its own members, who should work for one year, and that their report should then be published.

Mr. D. J. WHITTEMORE.—In the main I agree with the conclusions of Mr. Bouscaren as given previously in this discussion. I cannot, however, bring myself to the belief that different roads and their branches may have bridges of different ultimate strengths. Railways are operated by superintendents, not by engineers. While a superintendent may be well posted as to the capacity of structures upon the various branches of a line of road of which he has charge, he may be displaced at any time and a new superintendent appointed who may assume at once that all structures within his jurisdiction are of the same strength, and he is liable to send a train of maximum weight over any portion of his line. Of this I can cite an instance: An individual owning a patent car designed for carrying an enormous load had it loaded to its fullest capacity at one end of our line, and the division superintendent, without inquiry, started it on the way to its destination. It so happened when its journey was about half reached that the matter came to my knowledge, and while we would have been able to have safely transported the car to its destination, upon my representation of the matter to the general superintendent, its progress was arrested and one-half its load removed. General superintendents understand these matters pretty thoroughly, but they are not always able to control the action of division superintendents who are younger men, therefore I am strongly of the opinion that every company should have its structures on all its lines strong enough to safely sustain the heaviest traffic of the day.

I think it quite right that our States should enact laws requiring railway companies to have periodical inspection of structures by competent persons and also require said companies to use devices that are proved to conduce to the public safety, and we know the laws inflict proper penalties in case of their non-use, but I do object most strenuously to having men, calling themselves engineers, appointed, through political influence and receiving their appointments through State officials or by election from the people and not selected by the railway company itself, which is or should be a competent judge of capacity, to tell us how to do our business. An engineer appointed by a railway company has, or should have, his heart in the business, feel responsible for the safety

of every structure, and should he have a conviction that any structure on his division was faulty, his conscience would not permit him to neglect the matter until it was righted. Generally, I think that the railway companies of any magnitude in our country have, or are now inaugurating, a pretty thorough system of inspection of their structures; therefore, I say, let the legislation on this subject be general, and of such a character as will impel the railway companies to have thorough and competent inspection of their structures by their agents only. States should not enter upon this matter without being willing to assume responsibility, through neglect of their own agents.

While we have had many and valuable suggestions as to the inspection of bridges, we are anxious to ascertain the opinion of members as to what should be considered a proper rolling load in designing bridges for the present and future traffic. I am sure that superintendents and managers of railways will continue to increase the size and weight of carriages and the load carried thereon, until they find that tie and rail become insufficient and not an element of economy, and in doing this they will go beyond the limit of economy, as railways are now constructed. A general expression upon this subject will guide many engineers in their designs hereafter.

In regard to standard floor, I think that a universal floor cannot be well adopted for this reason: conditions are different in different parts of the country. Southern roads on our continent do not have to contend with the snow that we meet with in the northern States and Territories. In the northwestern States, where my field of work lies, and where the temperature is no more severe than is found in the New England States, I have seen snow so deep that men when shoveling out the track rested themselves by sitting down on the top of telegraph poles; and I presume there are several here present who have had analogous experiences in the northwest. While the climate in its general features is not widely different from that of our eastern States, the wide, open, rolling prairies permit what are termed blizzards, that pile snow to enormous heights. Without due consideration of these matters I commenced some years ago building the floor mentioned by Mr. Pegram, and put guard rails 9 to 10 inches outside of the rail; in some instances we lined this with iron. Since that time we found it necessary to construct between fifty and sixty snow-plows, or about one to every hundred miles, and any number of what we call flangers, and to operate these snow-plows and flangers safely, it has been necessary to place the guard rails instead of 10 inches outside of the rail to from 14 to 17 inches. While it may be well to recommend the Latimer guard on many of the lines of this country, I fear it will be difficult to introduce it on all. In regard to grade crossings, I am sure that it is not policy for this Society to express an opinion; density of population will control this matter.

When our company built into Minneapolis it was a small place, and we went across streets at nearly grade; now since the city has grown to its present size we are about to lower many of the crossings below the railway or above, as may seem proper. Had we been compelled to do this at the outset it would have been many years before that place would have secured a railway to it. The volume of traffic and importance of a highway for the public using the same, determines what is policy in such cases, and ordinarily the railway companies and the public are able to settle this matter satisfactorily.

ROBERT MOORE, M. Am. Soc. C. E.—I sympathize with Mr. Whittemore in what he says about the excessive loads which are put upon bridges. I think that the branch lines might perhaps co-operate with the engineer if he adopted a lower standard in his bridges, yet he can have no assurance that some abnormal load will not be put upon them. I am therefore very much in favor of building bridges, even of branch lines, up to a high standard, provided the money can be obtained; for, of course, this is, after all, the controlling consideration. But if you cannot do any better, I would build bridges to carry 2 000 pounds per foot, which is the old standard to which bridges used to be built.

Speaking of abnormal loads, I would mention the case of the transportation of our street cables. Within the last two or three weeks we have had pass over the bridge at St. Louis a number of these cables, of which the last one weighed over 90 000 pounds, and was on a car which could not have weighed less than 30 000 more, giving for a 30-foot car a load of 4 000 pounds per lineal foot, which is much too great for most bridges. It is, in fact, a load which bridges ought not to have to stand, as the damage to the track of even our best roads caused by loads like these is so great as to make them anything but economical.

Mr. D. J. WHITTEMORE.—It seems to me that there is another view to take of this matter—Mr. McAlpine can correct me if I am wrong, and that is, that in the early inception of railways in this country they could be operated after the rails were laid, and then the civil engineer was no longer required. Generally, as soon as an engine could pass over the road the civil engineer was dispensed with as soon as possible. Oftentimes he was looked upon during the construction as a necessary evil, one who spent money but did not earn any. In this way many railways were operated for about seven years, and by that time ran into bankruptcy. The successors of the bankrupt company then were forced to the conclusion that they required a civil engineer to direct, and replace the decayed and worn-out structures, and often employed the cheapest man they could get, brave enough to confer upon himself the title of civil engineer, to act as such.

W. J. McALPINE, Past President Am. Soc. C. E.—I want to say that I commenced engineering at a salary of $10 a month and board.

Mr. WHITTEMORE.—Nearly every railway company of magnitude on our continent at the present time, I am happy to say, finds it necessary to employ the best talent it can secure not only in the engineer service, but in every other department of railway service. Now there can be found men of as much culture, honesty and energy as can be found in any avocation in life; and any railway company that has not these factors cannot serve its stockholders properly. It is entirely unnecessary for me to make such remarks before the members of this Society, but we must remember that our proceedings are sometimes perused by men, not engineers, interested in railways.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

TRANSACTIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

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INSPECTORS AND BRIDGE WORK.

By SAMUEL TOBIAS WAGNER, M. Am. Soc. C. E.

READ AT THE ANNUAL CONVENTION, JULY 2D, 1887.

WITH DISCUSSION.

The object of this paper is to discuss the characteristics and work of inspectors, especially as regards their bearing on the bridge industries of this country, and to determine upon the most harmonious relations between them and the manufacturer.

Inspectors may be divided into two broad but eminently distinct classes, viz.:

First.—Those who know what they want, and know when they have it.

Second.—Those who do not know exactly what they want, and therefore are often at a loss to decide when they have it.

Manufacturers may also be divided into two classes, viz.:

I. Those who intend to give good work, who have a reputation at stake, and who value it.

II. Those who will resort to underhand dealings in order to pass off bad work, and whose object is to make money at the expense of their reputation.

The combinations of these four classes, under various conditions, is the principal subject of this paper; and although no definite rules can be laid down as to methods of procedure, nevertheless it is possible to adjust certain points which will tend towards a clearer understanding as to the scope and jurisdiction of both manufacturer and inspector.

In bridge work the percentage of inspectors per pound of iron is increasing very rapidly, and this fact makes it all the more important that a thorough understanding of the scope of inspectors be reached, as upon them depends, to a very large extent, the tranquil or ruffled close of a contract.

All railroads of any magnitude have their regular corps of inspectors, or special inspectors, under the chief or a consulting engineer, and bridges of any consequence which are left without an inspector are fast becoming things of the past.

The object of an inspector is to determine whether the contractor is living up to his specifications. The specifications should always be as complete as possible, and no contract should be let without them. There is nothing so unsatisfactory for both contractor and inspector as to try to accomplish an uncertainty in a satisfactory manner, and if they succeed in getting along well the conditions must be most favorable.

No contract should be signed without specifications, if anything is to be required and demanded, and neither party in signing should lose sight of what they are agreeing to do. I dare say many contracts are signed with perhaps merely a glance at the specifications, and then when the contractor, in the hurry of his work, is reminded by the inspector that some certain clause is not being complied with (of the existence of which, perhaps, he has never heard), it is sure to make trouble, especially if it is expensive to remedy. This at once makes unpleasant relations between the two, and only one party is to blame.

An inspector should not only have specifications and know them by heart, but should understand exactly what is meant, and be capable of saying whether the work, as performed, is in accordance with them or not. If his inspection is not to be final (a condition of things which should never happen), he should know what he has a right to accept and what to reject. There should be but one inspection of raw material, one inspection of work leaving the shops, and one of the finished structure, and each should be final for what it was made.

An excellent plan to be observed throughout a contract is that of having all material that has been accepted from the mills stamped by the inspector. In the same way the inspector's stamp should appear upon every finished bridge member, and thus show that it has been accepted.

It is very unfortunate, both for railroad companies and manufacturers, that there are inexperienced inspectors for bridge work. It too often happens that men of no theoretical or practical training in any branch of engineering, are deemed competent to decide upon the merits of work when they do not know the principles of its construction, and it is this class of inspectors, under certain circumstances, who are very annoying to the contractor and cause him most trouble.

A man's disposition determines, in a large measure, his success as an inspector. A naturally suspicious man makes his own life a burden, besides being a source of needless worry to all around him; while one free from suspicion and with even an ordinary amount of common sense and intelligence can get good work and make no trouble even if his technical knowledge is small.

If an inspector is determined to make things unpleasant he can always succeed in so doing, as his power for the time is necessarily great; but unless his reasons are good he commands little consideration from the contractor, and soon becomes unpopular.

The contractor, upon beginning work, should notify the inspector at once of the fact, in order that he may avoid delays and unnecessary expense.

In the standard specifications for material and workmanship of iron and steel structures adopted in this country by the leading bridge builders, a clause is introduced bearing upon this point which is excellent; part is herewith quoted:

13. "The inspection and tests of material will be made promptly upon its being rolled, and the quality determined before it leaves the rolling mill. All necessary facilities for this purpose shall be afforded by the manufacturer, but if the inspector is not present to make the necessary tests, after due notice is given him, then the contractor shall proceed to make such number of tests as may have been agreed upon," etc.

By this means all raw material reaching the bridge shops will have been inspected and tested, and no extra handling should be allowed as is now too often the case. In the inspection of the raw material from

the rolling mill the inspector should pass upon the straightness of the individual pieces, if he will not allow means of remedying this defect afterwards.

In many of the English and French shipyards not a pound of iron or steel will be accepted without the inspector's stamp, and if this rule were adhered to more closely in America, much trouble and serious expensive delays could be avoided.

Assuming that all the iron for a bridge has been rolled, tested and inspected for surface defects, straightness, etc., and has been delivered at the shops, the question then arises as to what inspection should be made as the work progresses, and where the same should be examined. As this question is difficult of solution, it may be well to briefly divide up the different classes of work on a bridge, and to take an ordinary through span as an example.

We may divide the work upon this into:

1. Riveted members.	Floor beams.	Intermediate posts.
	Stringers.	Struts.
	Chords and end posts.	Pedestals and wall-plates.
2. Forgings.....	Eye-bars.	Upset and eye rods.
	Clevises, and other blacksmith work.	
3. Machine work.....	Pins, rollers, turned bolts, etc.	

We can omit any discussion of sections 2 and 3, as any inspection before the final one is entirely unnecessary, except, perhaps, an examination into the methods of manufacture if special methods are required in the specifications. In case no special operations are demanded, the inspector has no right to insist on a special method being adopted by the contractor, if, in the end, the work is satisfactory.

Under the head of riveted members so many requirements are included that we cannot arrive at so rapid a solution. Most specifications do and should cover almost all the separate steps in manufacture from the raw material to the finished member.

Assuming, for example, a section of the top chord of a bridge, let us follow it through the shop. It is punched, riveted, faced and bored, and about each operation something is usually specified.

In the punching the only necessary point for the inspector to satisfy himself upon is the relation between the punch die and rivet to be used. If this is not specified no inspection is necessary, but it is apt to appear in almost all cases.

In the assembling of the punched parts for riveting, he may have to satisfy himself that the work has been properly punched, and that no gouging of holes is allowed. Unless his contract is small, or he has plenty of assistance he will not be able to devote much of his time to this part of the work. At this point the inexperienced inspector usually brings up the drift question, and some arguments are usually necessary to convince him that it is as yet harmless.

When the member is being riveted he may with propriety watch the drift, and as soon as the member is completely riveted should pass (by marking) upon the quality of the riveting and straightness of the member. The member is now faced and bored and the final inspection made for length and distance between pin holes, and the final stamp placed upon it, after which it is painted or oiled and ready to ship.

It seems to be a disputed point among inspectors whether these final measurements are necessary, as in some cases they omit them entirely, while in others the manufacturer is checked on every point. It seems to the writer that these extremely careful measurements are unnecessary, especially if the same contractor erects the structure. Of course the inspector may desire to check them up for his own satisfaction, and it no doubt eases his conscience.

The instrument generally used by those who use and check the final measurements is the steel tape, and each inspector making the measurements wants his tape taken as the standard. For the purpose of checking measurements within one-eighth of an inch the steel tape will answer fairly well, but further than this it should not be relied upon. For finer checks than one-eighth of an inch the shop standards should be used, as it must be assumed that the whole bridge will be built from them.

For these fine measurements the writer prefers standard steel poles.

If the inspection is not made on riveted members as above, the manufacturer may be seriously delayed if all the inspections mentioned are intended to be carried out and a very strict inspector on hand. There should therefore be a distinct understanding between contractor and inspector as to just what points are to be specially inspected and the work arranged in the shops to suit. If the inspection is to be rigid upon straightness, then the work should be inspected as soon as it has been riveted.

On the other hand, if the contractor understands just what quality of

workmanship is required, then the danger in having one final inspection is lessened, but not entirely averted, whereas with some inspectors it is not safe to proceed more than a step at a time.

To insure prompt execution of the work the inspector should pass upon it promptly and decidedly, and should know just what to give and take in case of a question on a minor point. An inspector who adopts a standard within the reach of mortal man, and sticks to it, has less trouble with the manufacturer than one who is changing constantly. The two arrive at a distinct understanding and each know when they have passed the line.

To insure pleasant relations between a rigid inspector with detailed specifications, and a contractor with a reputation, the inspector on the one hand must:

First.—Have had some experience, and have and exercise common sense, besides thoroughly understanding his specifications.

Second.—Be on hand promptly and see all the material tested and inspected.

Third.—Have a distinct understanding with the contractor as to what will be expected.

Fourth.—Be on hand while the work is progressing on his contract and keep himself informed as to when he will be wanted.

Fifth.—Inspect the work as it progresses, and not leave it until it is ready to ship.

Sixth.—In case of a piece of questionable work, reject it for the moment if other work is awaiting inspection, and decide finally at a more opportune time. The writer has seen an inspector halt and deliberate for a whole day over one piece of work, while other urgent work was awaiting his inspection.

On the other hand, the contractor, in order to carry out his part of the programme, must:

I.—Determine to live up to his specifications as he understands them.

II.—Arrange with the inspector in detail where the different inspections of the material and work are to be made.

III.—Give the inspector ample notice when he will be wanted.

Perhaps it would be advisable to have printed forms as given below to be filled out by the contractor and inspector at the beginning of a contract, and each retain a copy.

INSPECTION OF RAW MATERIAL.

....., 18..

Contractor's Order. *Inspector's Order.*

DESCRIPTION.	TO BE MADE AT.	TESTS REQUIRED.
Universal plates		
Sheared plates.....		
Angles		
Channels, etc.....		
Bar iron.....		
Pin iron.....		
Castings.....		
Other shapes		

Contractor.....
Inspector.....

This would have the effect of systematizing the testing and the location at which the material is to be made, thus furnishing in a proper manner a great deal of information, which the inspector has ordinarily to find out from time to time as best he can.

It will be impossible to follow any regular course for the riveted work, as everything depends upon circumstances; but the writer cannot too strongly urge that the inspection should in no case be left until the work is entirely finished, except where absolutely necessary, especially if inspector and contractor are strangers. It is admitted that this method of examining the work at various stages in its progress makes more work for the inspector, but if everything is to be examined it is merely a question of when it is to be done. Besides, if any alterations are to be made they cannot be made too soon in the progress of the work, as they are easier remedied and the damage done to the piece made very much less.

A very unfortunate case is that of rejection of work by an inspector which the contractor feels is unjust, because the only appeal is to the inspector's superior, and in nearly every case he is sure to be sustained in his decision. If the inspector determines not to yield, the contractor in most cases must give up the fight. This is one of the most exasperating positions for him to be placed in, as he virtually has no redress. Could not a clause be inserted in specifications providing for arbitration in a case like this?

As it now stands, the only thing a contractor can do is to be very careful in signing a contract to ascertain who the inspector of the work is to be, and if the same is well known for giving trouble, throw up the contract unless another is substituted. This method is in existence; its use is unpleasant, and it is very much to be regretted that there is apparently no better way out of the difficulty.

A rather remarkable condition of things may here be noted: As good work is almost invariably obtained by inspectors who have no serious difficulty with contractors, as by those who are constantly at variance with them, and it will be found in most of these cases that the reason is their uniformly just decisions, thus giving the contractor no ground for complaint.

An inspector's decision once given should be final, and if he does not use a stamp it is advisable that he should accept everything in writing, although the stamp is much the preferable way.

The writer, although unwillingly, is in favor of a black list of troublesome inspectors to be circulated among bridge-builders, but feels that if the matter were to receive proper attention the most serious points that lie as stumbling blocks between inspector and contractor could be removed by a system of arbitration; that this would place the blame where it was due, and thus avoid troubles that, if not thickening, are growing none the less.

DISCUSSION.

Mr. J. B. JOHNSON, M. Am. Soc. C. E.—I would like to ask whether Mr. Wagner can get better results with steel measuring rods than with steel tapes. In my experience the steel tape is the most accurate way of measuring that has yet been devised.

S. T. WAGNER, M. Am. Soc. C. E.—In answer to that, it has been our experience that steel tapes expand or contract quicker than the mass of the metal they are on. And it is one disadvantage that most of the steel tapes are divided rather crudely; it is very seldom that you see a steel tape divided into less than an inch. In the case of the steel rod, at least one such as I have seen used, the division is very sharp, and when they are only divided into feet, the inch and fractions of an inch can be measured off very closely with the standard 12-inch steel rule. I have seen recently some steel tapes which are divided into sixteenths of an inch, and in which the divisions are very sharp. As for these I cannot say how they would work, but a great many inspectors have brought steel tapes and have called attention to the fact of certain

differences, but the marks were not exact and when we have measured them we found that we could not agree with the inspectors. In the works where I am engaged they have discarded the use of the steel tapes except for measurements not including fractions of an inch.

Mr. J. B. JOHNSON.—This brings up the general subject of long standards of length. There are many difficulties with long standards of any kind. The universal difficulty of temperature is an additional difficulty with a long standard, affecting its absolute length. There are no two standards that will agree and the trouble increases with the length. Now, it seems to me there should be a greater effort to obtain accuracy in long standards, say in 50-foot or 100-foot tapes or chains, but in tapes rather than in chains. At present we can only rely on the maker's brand, and heretofore there have been few facilities in this country for getting absolute lengths of tapes. It is now possible to do that. There are now in St. Louis two tapes, 300 feet long each, which are absolute standards. They are absolute lengths that have been determined by comparison with United States base lines so that the lengths are known with an accuracy of one-millionth part of the length. Whether it be the standard meter bar of the French archives, or whether it be the base line 4 or 5 miles in length, there never has been any means devised for getting the absolute length over about the one-millionth part; but that may be done with the steel tape, and the steel tape may be used for getting other lengths with that same degree of accuracy. It is now absolutely proven by the measurement of base lines on the Missouri River Survey, the details of which are printed in the Report of the Missouri River Commission for 1886 and 1887, that base lines can be measured with a steel tape as accurately as has ever been done with the most elaborate apparatus ever invented. So that men who are engaged in the most accurate measurements are coming round to the steel tape as being the best and most accurate standard that has been used; therefore, I think that it should not be dismissed from such work as this too hastily. The probability is that if good results have not been obtained from it, it is because it has not been properly used. Of course it should have accuracy of subdivision.

It seems to me that if a small tape, say $\frac{1}{2}$ of an inch wide and $\frac{1}{64}$ of an inch thick, of about 0.002 of a square inch in cross section could be laid upon an iron member, it would very soon reach the temperature of that member; the small tape laid upon the iron member would arrive at the exact temperature of that member; that is a result that is to be desired. If you take the large iron rod it would not arrive at the temperature of the member in a considerable time. Of course we must know the various constants of the tape, but when the tape is compared with some other standard tape you then get these facts. If intelligently used, the steel tape is destined to become, I believe, the most valuable means of accurate measurement available to engineers.

A. M. WELLINGTON, M. Am. Soc. C. E.—Mr. Chairman, did I understand, that with these 300-foot steel tapes, base lines can be measured as accurately as by the cast-iron apparatus?

MR. JOHNSON.—Yes, sir.

MR. WELLINGTON.—In any weather?

MR. JOHNSON.—Not in ordinary weather, but in selected weather. You must give the tape a fair show, and you must get the actual temperature of that tape, say to a half, or a tenth, of a degree, but that whole question has been thoroughly investigated. If the base line be measured four times and scratches on zinc strips made for each 300 feet, and the temperature is not the same on any two measurements, then these marks do not correspond.

The comparative values are only known after they have been reduced. You have then an absolute check for each 300 feet, and that furnishes a good opportunity for obtaining the probable error. With proper precautions, in the best weather, a probable error of one in one million is readily obtained. The tapes are supported on a series of wire hooks, every 20, or 30, or 40 feet; if these hooks are not placed at the same distance apart, then, of course, the effect of the hanging loops must be introduced, but that submits readily to accurate computation. The tape is stretched by a weight which hangs by a lever so that there is no friction in getting the stretch. The thermometer is of the same temperature as the tape because the whole atmosphere is of the same temperature. I did not mean to call up the matter of base-line measurements, but it serves as an illustration to show that the engineer should not dismiss the use of the tape too summarily.

J. F. FLAGG, M. Am. Soc. C. E.—I would like to ask if, after the length of the tape has been ascertained by comparing it with the base line, whether that was afterwards used for measuring another base line to see how it compared with that? After you have obtained the length of the tape, whether it is tried on another base line.

MR. J. B. JOHNSON.—That has been done in Sweden, but not yet in this country. It is to be done soon; another base-line is soon to be measured that is of the same standard of accuracy. * The tape should be used on a still and cloudy or foggy day, because it is a very sensitive standard, and its temperature could not otherwise be accurately determined by a mercurial thermometer.

* In 1886 one-half of the Olney Base Line, in Southern Illinois, was measured three times with the Mississippi River Commission Tape. The length measured about 10 816 feet. In 1887 the entire base line was measured twice with the same tape, the length being about 21 633 feet. From these five measurements there resulted the following values for the length of the tape.

	FEET.		
1. 299.07469 2. 299.07581 3. 299.07532	Mean of first measurement.	=	299.07527
4. 299.07528 5. 299.07522	Mean of second measurement.	=	299.07525

See Report Missouri River Commission for 1887.

There are now in this country two absolute standards, each 300 feet long. One is the property of the Mississippi River Commission, and the other is the property of Washington University, St. Louis. The co-efficient of expansion of the Commission's tape was determined by myself by continuous observations for four days and three nights, with average temperature of some fifty degrees. Micrometer microscopes were mounted on fixed pillars over the ends of the tape, which was stretched by a 16-pound weight. The entire tape was inclosed in a wooden box, and suspended from hooks every 16 feet. The stretching weight was slung from a noose, which was kept adjusted to an angle of 45 degrees with the vertical. Its co-efficient was found to be 0.00000699 ± 4 in the last place. Its modulus of elasticity was found to be 27 400 000. Its absolute length was obtained by measuring the Olney base line.

The Washington University tape was standardized by comparisons at two widely different temperatures with that of the Mississippi River Commission. I may say that co-efficients of expansion of steel standards of length have been found to vary from 0.0000048 to 0.0000070, a variation of nearly 50 per cent.

F. COLLINGWOOD, M. Am. Soc. C. E.—How do you preserve the accuracy of the length of the tape?

MR. J. B. JOHNSON.—I do not understand that the mere fact of winding the tape changes its length. After you exceed its elastic limit its length is increased, but a steel tape is so thin that it never takes a permanent set by winding upon a reel.

MR. COLLINGWOOD.—Of large size?

MR. JOHNSON.—The reel is about 6 inches in diameter.

MR. COLLINGWOOD.—Is that a small diameter?

MR. JOHNSON.—Medium, I should say. The tape is $\frac{1}{2}$ of an inch wide, and about $\frac{1}{64}$ of an inch thick.

Mr. WAGNER.—I would like to say, that from what I know of steel tapes it is not so much the steel tape itself as the number of steel tapes that has to be contended with. The inspector comes and complains that the work is long or short by his tape. It is mainly with this that we experience the trouble. If steel tapes are properly used and properly devised, then, with proper care, very good work can be obtained, but each inspector comes along and says that all the work has got to be done by his tape.

J. J. R. CROES, M. Am. Soc. C. E.—Would it not be better for the manufacturer to furnish the steel tape to the inspectors? The cost would not be very great and the manufacturer would thus give the inspector the standard by which all the work would be laid out. In that way harmony could be preserved.

ELIOT C. CLARKE, M. Am. Soc. C. E.—I would like to ask, whether the use of wood for accurate measurement is safe? I know it has a bad reputation; but in measuring lines under the Detroit River, we used rods

10 feet long. We selected with great care some pieces of black walnut, and, after having them very thoroughly boiled in oil, made four rods, putting little metal strips at each end, and we had great success with them; we never had any trouble from moisture of the wood. It seems to me that wood, properly prepared, for many purposes would answer very well.

Mr. J. B. JOHNSON.—If the measurements are not to be made with the utmost accuracy, wood, I think, is a very satisfactory standard, but for extreme accuracy it will not do. I have compared 3-meter painted pine level rods, with absolute standards, for weeks at a time, by means of micrometer microscopes, so that the facilities were good for getting very accurate results. The rods were thoroughly tested and were treated exactly alike, and were stood vertically upon one end, so that there should be no good reason why they should change their lengths; but each rod had a different curve of changes; they were not reliable.

A MEMBER.—How large were they?

Mr. JOHNSON.—About 10 feet long. The extreme changes amounted to about half a millimeter; that is, about 1 in 6 000. The graduations were on the surface, however, and the changes noted might have resulted from deflections. End comparisons, or comparisons on the neutral axis, might have shown no change.

Mr. COLLINGWOOD.—Did the gentleman intend to say that the inspector's opinion should, in any case, be final?

Mr. WAGNER.—Yes, sir; I do think that when an inspector passes upon a piece of work he should not have the right to reject it afterwards, unless there is something of serious consequence; he ought not to have the right to change his opinion.

H. B. SEAMAN, M. Am. Soc. C. E.—If the fault is not seen by the first man it will be condemned by the second.

Mr. WAGNER.—If the work is bad it ought to be condemned immediately. If there is anything wrong that would injure it it ought to be condemned by anybody interested in it; but if there is only a minor point in view, I think the contractor should not be put to any expense after the inspector has once passed the work.

Mr. COLLINGWOOD.—I think that very often the contractor would like to appeal from the inspector's decision, and I think that a contractor ought to have that right. But in some cases there may have been something which could not be seen at the time which can be seen later on.

Mr. WAGNER.—I agree with the gentleman fully.